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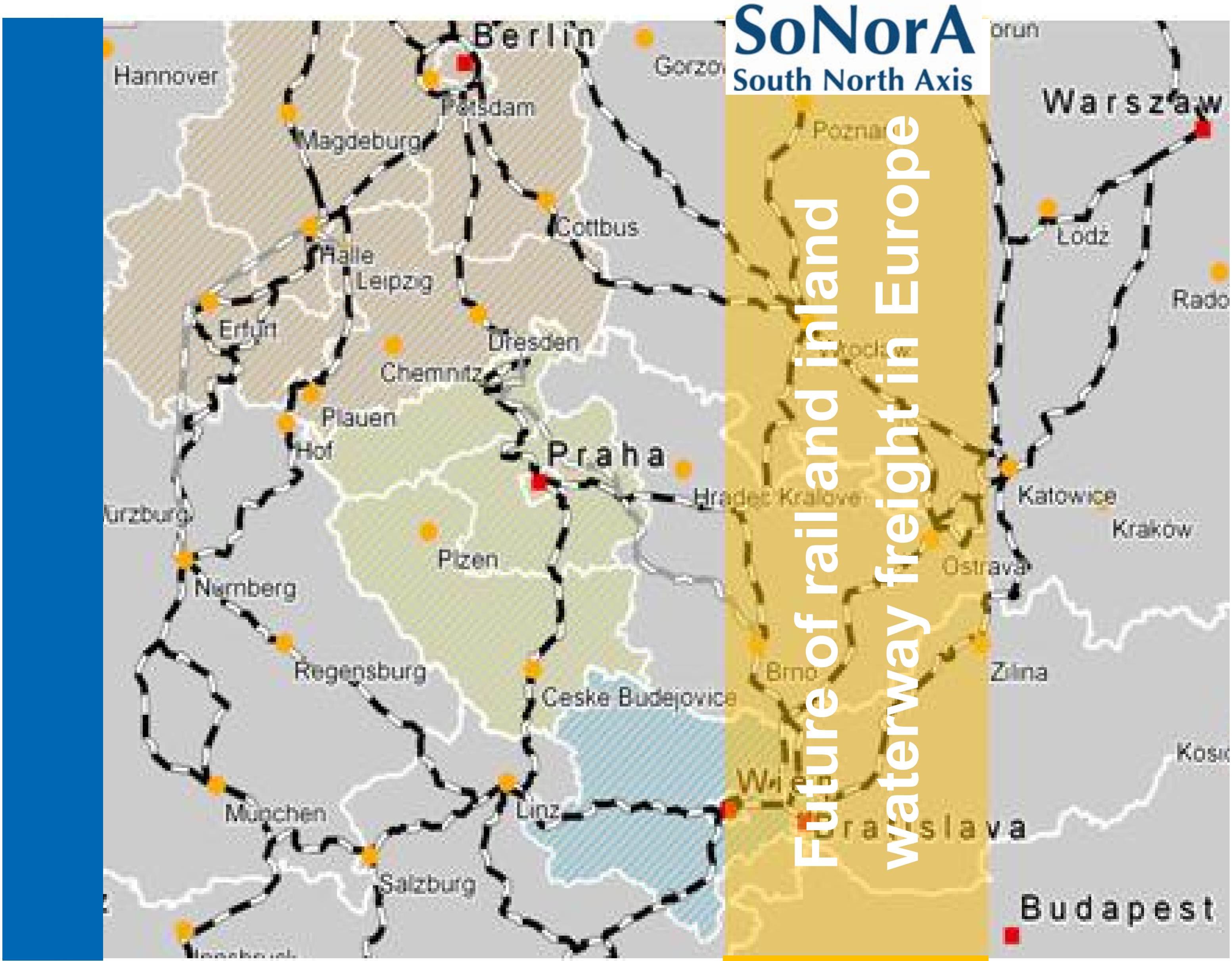
SoNorA
South North Axis

Future of rail and inland waterway freight in Europe



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Future of rail and inland waterway freight in Europe

Proceedings of the 6th SoNorA University Think Tank Conference (České Budějovice)

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15th of October 2010

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INTRODUCTION

SoNorA (South-North Axis) is a transnational cooperation project of the European Union which aims to improve the infrastructure and services in the south-north orientation within Central Europe. An integral and important part of SoNorA is the University Think Tank as a network of transport scientist which has three main roles and tasks within the project:

Firstly, it aims on the creation and consolidation of a network of universities in Central Europe which are related to research and education in transport and/or spatial planning. These partners participate in SoNorA conferences, round-table discussions, the writing of scientific articles, and further research projects emerged out of SoNorA.

Closely related to point one, the second task of the Think Tank is to generate inputs for the whole project. The Think Tank gives methodological support to project partners and creates strategies and inputs for SoNorA. These scientific papers are presented on separate conferences during the regular SoNorA consortium meetings.

Thirdly, the Think Tank reviews the 24 core outputs of the project which are generated by the project partners. The core outputs will be presented to the Think Tank by the partners on the consortium meetings and then will undergo a scientific review process including ex-post-analysis and best-practice identification.

The Think Tank consists of transport researchers of different faculties and institutes of various Central European countries. It is planned to organise ten Think Tank conferences, thus one on each consortium meeting. Each conference deals with a specific topic of transport research which is related to the content of the core outputs to be delivered on that time. The topics of the past and future Think Tank conferences are the following:

No	Date	Place	Topic
1	Feb '09	Praha	Get to know
2	Jun '09	Gdynia	Transport infrastructure between the Adriatic and the Baltic Sea; Transeuropean Networks of Transport in Central Europe; Simulation and modelling, forecasting and infrastructure
3	Nov '09	Potsdam	TEN-T core network; European and national railway policies
4	Feb '10	Portorož	Infrastructure and regional development; Infrastructure, transport and trade; Infrastructure and society
5	Jun '10	Erfurt	Railway logistics and rail cargo
6	**Oct '10**	**České Budějovice**	**Future of rail freight; Future of inland waterway freight**
7	Feb '11	Trieste	Harbour hinterland transports
8	Jun '11	Szczecin	Transport and the environment; Sustainable transport

9	Oct '11	Bologna	Preparation final conference
10	Feb '12	Venezia	Final conference

The last SoNorA University Think Tank conference was held on the 17th of June 2010 in Erfurt (Germany) and was focused on the topics: railway logistics; rail cargo.

The conference documented in this proceeding was held in České Budějovice, Czech Republic, on the 15th of October 2010. The main focus of this 6th SoNorA University Think Tank conference was about:

- Future of rail freight
- Future of inland waterway freight

Selected members of the Think Tank have written five scientific papers on different aspects of these topics which were presented at the conference in České Budějovice. The authors are from KTH Royal Institute of Technology (Sweden), Institute of Logistics and Warehousing (Poland), University of Gdańsk (Poland), Hungarian Academy of Sciences and the Széchenyi István University Győr (Hungary).

The papers are dealing with railway freight transport along the corridors of Scandinavia-Germany and from Central Europe to South-East Europe as well with east-west transport in general. The second part covers the perspectives of inland waterway freight transport in Central Europe and the topic of river transport planning.

This is the fifth volume of a series of “Proceedings of the SoNorA Think Tank Conferences” where all accepted contributions of the authors are presented. It shall provide a basis for further discussions and be the start of a successful scientific network in the field of transport and spatial planning.

DEVELOPMENTS IN RAILWAY FREIGHT TRANSPORTATION BETWEEN SCANDINAVIA AND GERMANY

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ABSTRACT

This paper investigates recent and ongoing developments in freight transportation by rail between Scandinavia and Germany. Present capacity constraints are identified. Infrastructure investment plans until about 2020 are reviewed. Technical standards between the national railway networks are compared and common best practices are proposed. Among the conclusions are recommendations to unify the operation of long freight trains, to raise axle loads and to adopt enlarged, flat-top loading gauges.

1 INTRODUCTION

1.1 Background

Growing international trade is one of the results of continuing international integration. Transportation demand keeps rising, and there is a pronounced political will to shift traffic from road to rail for reasons of sustainability. Whereas the European railway network of the past was fragmented along national borders, deregulation aims to simplify cross-border operation.

The German economy is the largest of the European Union, and the German railway network carries the most freight of the EU. Of the national railway networks in the EU, the Swedish has been reported as the most efficient in freight transportation.

1.2 Purpose and scope

The purpose is to identify measures to further competitive freight transportation by rail between northern Germany and Scandinavia by establishing common standards for operational and infrastructure improvement for the long term. The aim is for the railway to be able to handle a greater share of international freight transportation in a sustainable way, contributing to lowered energy consumption as well as reduced greenhouse gas emissions.

The most important factors for transportation efficiency and parameters influencing the shipper's choice of mode will be examined, and a common strategy will be proposed.

Included in the study are the railway networks and operations of Finland, Norway, Sweden, Denmark and Germany and the links connecting these.

1.3 Method

The study will investigate the present transport flows, modal distribution, and factors influencing demand.

A survey is made of the existing railway networks, recent capacity utilisation, technical standards affecting capacity and productivity, and existing plans for infrastructure improvement.

Finally, weak links are identified, and common, best practice standards are proposed.

2 TRANSPORTATION DEMAND AND ROUTING

As Germany is the leading trading partner of Denmark [1] and Sweden [2], as well as the second biggest trading partner of Finland [3] and Norway [4], it follows that transportation demand between Scandinavia and Germany is high. The transport flows between Scandinavia and Germany also include a large share of transit freight to and from nations beyond Germany. Large trade commodities in this north-south axis include paper, steel, machinery, food and automobiles.

The transport modes available include:

- ship,
- train,
- truck,
- intermodal, i.e. combinations of the above, including ferries.

Main cross-border rail and train ferry routes are shown in Figure 1.

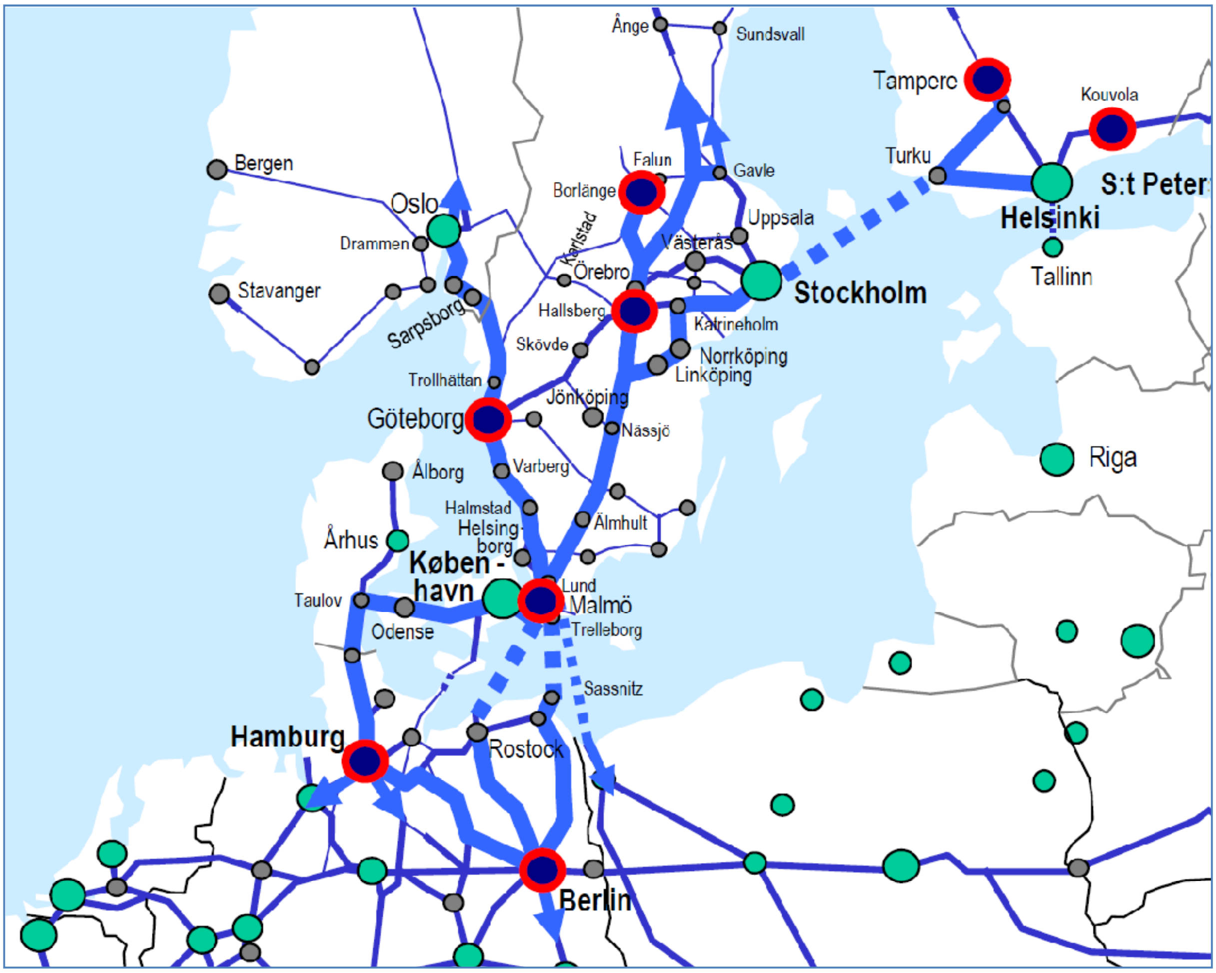

Figure 1: Cross-border railway routes of southern Scandinavia and northern Germany in 2010

Railway connections with Finland (by ferry) and Norway pass through and converge in southern Sweden at Malmö, from where parallel links with Germany are available: directly by train ferries Trelleborg-Rostock and Trelleborg-Sassnitz, as well as an overland route across the Øresund bridge and through Denmark to Hamburg. The more direct route by train ferry Rødby-Puttgarden currently does not handle freight trains. For trucks, ferries are also available between Norway and Denmark as well as Germany, and between Finland and Germany.

The approximate market share per transport mode between Sweden and the rest of Europe is shown in Table 1.

Freight origin/destination	**Freight market share by tonnage**			
	Ship	**Train**	**Truck**	**Total**
Finland	38 %	7 %	55 %	100 %
Norway	38 %	10 %	52 %	100 %
Denmark	50 %	4 %	46 %	100 %
Western Europe except UK	46 %	15 %	40 %	100 %
United Kingdom	59 %	0 %	41 %	100 %
Spain & Portugal	46 %	0 %	54 %	100 %
Eastern Europe, standard gauge	35 %	13 %	53 %	100 %
Eastern Europe, broad gauge	81 %	0 %	19 %	100 %

Table 1: Transportation between Sweden and the rest of Europe in 2006, excluding ore and petroleum [5]

The market shares for ship and truck are higher than for train throughout. The highest market share for train is achieved for those origins and destinations which are proximate and which share the same track gauge, thus enabling direct shipment without exchanging bogies. The notable exception is Denmark, where wagonload freight has practically ceased.

As trains and trucks are able to compete head-on for the same inland origins and destinations, a comparison of the net tonnage carried by each is given Table 2, with data for 2007.

Route	**Tonnage of freight carried (1 000 tons)**					
	By train			**By truck**		
	By ferry	**Øresund bridge**	**On land**	**By ferry**	**Øresund bridge**	**On land**
Norway↔Sweden	0	0	1 628[1]	292	0	2 187
Finland↔Sweden	438	0		4 897	0	
Denmark↔Sweden	11	2 239	0	7 595	4 463	0
Germany↔Sweden	2 544	0	0	14 727	0	0
Poland↔Sweden	596	0	0	3 933	0	0

Table 2: Train and truck share of Swedish cross-border transportation in 2007([1]: Excluding iron ore) [6], [7]

As shown, the largest cross-border flows of goods by train and truck involving Sweden are with Germany directly, by ferry, while the second largest flows are with Denmark. It is also seen for every single relation in Table 2 that the tonnage moved by truck dominates over that moved by train.

The cross-border freight flows through Denmark recently are dominated by transit freight, while Danish domestic freight carried by train has dwindled over the last decade. In 2008 of the freight tonne-kilometres produced by train, only 7% was in domestic traffic, while

19% was in import and export traffic, and the remaining 74% was in transit traffic, thus passing between Sweden and Germany or beyond [8]. The recent trend shows that transit freight is growing significantly, see Table 3.

Geographical limitation	Tonnage carried (1 000 tons)				
	2004	2005	2006	2007	2008
To Denmark	1 917	1 694	1 858	1 665	1 477
From Denmark	1 069	1 003	899	778	596
Transit	3 171	3 144	3 311	3 680	4 555
Total	6 157	5 841	6 068	6 123	6 628

Table 3: Danish cross-border freight by train [8]

The type of freight can be characterised as either wagonload (here including unit trains) or intermodal (including containers, swap bodies and trailers). Recent trends for Swedish cross-border freight by train are shown in Table 4.

Transport system	Tonnage carried (1 000 tons)				
	2004	2005	2006	2007	2008
Wagonload	7 180	7 115	6 788	6 791	6 681
Intermodal	1 261	1 395	1 657	1 930	2 263
Total	8 441	8 510	8 445	8 721	8 944

Table 4: Swedish cross-border freight by train (excluding iron ore) [9]

As seen by the data, fallen somewhat in recent years, while intermodal shipments show a high growth rate, having nearly doubled from 2004 to 2008. Thus there is reason to assess both wagonload and intermodal traffic.

3 COMPETITIVE ENVIRONMENT

To map what factors most influence the shippers' choice of transport mode, a survey was done from 2002 to 2006, covering the logistics managers of some 100 corporate shippers in Sweden [10]. The survey covered seven variables characterising the transport services offered, and found the highest elasticity of demand (positive or negative) with respect to, in descending order:

- transport cost
- on-time delivery
- transit time
- environmental impact
- loading time
- damage
- service frequency.

Thus, in assessing the competitiveness of alternative transport modes, there is reason to focus in particular on cost, on-time performance and transit time.

Of these factors, on-time performance is closely related to the capacity utilisation along the route taken, as a too high capacity utilisation means that there are small margins to recover from any occurring delays and disturbances. In addition, ferry as well as bridge crossings are inherently susceptible to delays due to speed restrictions or even closure in case of adverse weather conditions. The Øresund bridge, as an example, is closed for road traffic from 25 m/s and for freight trains from 27 m/s actual wind speed.

Transit time and service frequency are shown by the train operators together with their schedule information, in some cases supplemented with comparisons of CO2 emissions for train vs. truck for each origin-destination pair, as a measure of the environmental impact.

4 PRESENT SERVICES

While wagonload freight is consolidated into long-distance freight trains at the marshalling yards where rail lines converge, intermodal shipments are hauled between intermodal terminals, in many cases by direct trains, i.e. without intermediate switching. The main marshalling yards and intermodal terminals in southern Scandinavia and northern Germany are identified below.

4.1 Wagonload service

The railways of both Norway and Denmark have largely ceased to handle domestic wagonload freight. In contrast, wagonload service is still significant in Finland, Sweden and Germany, domestically as well as internationally. In the cross-border traffic flows, much of the wagonload freight consists of paper, steel and machinery, much of the paper originating in the north.

Finland's largest marshalling yards are all located in the southern part of the nation, in order of size: Kouvola, Tampere and Rihimäki. Connection with the west European railway network is by changing bogies between broad and standard gauge and transfer by daily train ferry between Turku and Stockholm (or by bridge between Tornio and Haparanda in the far north).

In southern Norway, international wagonload traffic is handled at terminals in Drammen and Sarpsborg (Rolvsøy) [11].

Sweden has four main marshalling yards: Borlänge, Hallsberg, Göteborg (Sävenäs) and Malmö. Hallsberg consolidates much of the freight from northern and central Sweden, dispatching several trains per day across the Øresund link through Denmark to Hamburg (Maschen). Wagonloads are also shipped by train ferry between the ports of Trelleborg in Sweden and Rostock and Sassnitz in Germany.

In northern Germany, the main marshalling yards for long-distance service are located in Hamburg (Maschen) and near Hannover (Seelze) and Berlin (Seddin). Hamburg dispatches daily direct freight trains through Denmark to southern Sweden.

4.2 Intermodal service

Intermodal terminals are located near the main population centres as well as at the main seaports and where main highways and railway corridors intersect. The existing terminals are expanding rapidly, and many new terminals are being built.

In south-eastern Norway the National Transport Network includes Oslo (Alnabru) and Drammen intermodal terminals [11]. By far the busiest intermodal terminal in Norway is that of Alnabru, which originates weekly trains through Denmark and Germany to Rotterdam, and daily trains to Trelleborg in southern Sweden with onward connections to Germany.

In Sweden, among the intermodal terminals and seaports identified by the Government as most important for the future, those in the south are, in descending order of the number of units handled (in 2005) [12]: Göteborg, Malmö, Stockholm, Älmhult, Hallsberg, Jönköping. In addition, Helsingborg and Trelleborg ports are identified together with Malmö as strategic bridge ports for transports to and from Denmark and Germany [13]. Since 2005 a number of new intermodal terminals have opened, among them Katrineholm and Nässjö. Direct trains to and from Germany are handled by the intermodal terminals at Katrineholm, Nässjö, Göteborg, Helsingborg and Malmö.

In Denmark, the main intermodal terminals are, in descending order of the number of units handled, Høje Taastrup (near København) and Taulov, of which Taulov is connected by direct trains with Malmö as well as Hamburg (Billwerder) and through Germany with points in northern Italy.

4.3 Unit train service

In addition to wagonload trains and intermodal trains, there are a number of dedicated unit trains for specific customers and commodities, generally bypassing the marshalling yards. These include unit trains for auto parts between Sweden and Belgium and for forest products from Sweden to Germany, in both cases transiting through Denmark.

4.4 Existing capacity bottlenecks

Capacity utilisation for a network link or a node (junction or yard) is generally expressed as the number of trains operated in relation to the theoretical maximum throughput. This may be evaluated per whole day or for a fraction of a day, e.g. for the busiest hour. The higher the utilisation, the more sensitive the system is to disturbances, i.e. a primary delay by one train will cause knock-on effects on other trains, and recovery becomes difficult.

Although the exact definitions and criteria may differ between the national infrastructure managers, the capacity utilisation is nevertheless useful to identifying actual or potential bottlenecks. Data for 2008 and 2009 are available from the infrastructure managers, and identify the following existing bottlenecks on the mainlines connecting Scandinavia and Germany:

- Norway: Oslo-Ski (double track) [14];
- Sweden: Stockholm (double track), Hallsberg-Degerön (single track), Höör-Malmö-Lockarp (double and quadruple track, junctions), Varberg-Hamra (single track) [15];
- Denmark: Øresund-København-Roskilde-Ringsted (double and quadruple track), Odense-Snoghøj (double track), Vamdrup-Vojens (single track), Tinglev-Padborg (single track) [16];
- Germany: Bad Schwartau-Lübeck-Kücknitz (single-track, non-electrified until 2008), Hamburg (multiple track, junctions), Stelle-Lüneburg (double track) [17].

While the above gives a picture of the actual, recent situation, one must keep in mind that this identification of bottlenecks is based on the trains actually run, and says nothing of the possible demand for additional services, either present or future. Thus, it needs to be supplemented with demand estimates (forecasts) and simulation of the whole traffic flow including any additional services required.

5 INFRASTRUCTURE AND OPERATING PRACTICES

5.1 Strategic infrastructure plans

Existing infrastructure and operating practices are reviewed, as well as those improvements which are already included in the present plans. The national plans for infrastructure investment cover approximately a decade, and are generally updated after half that period. Of the plans now in effect, several were adopted recently. A summary follows:

- Finland: Transport Policy Guidelines and Transport Network Investment and Financing Programme Until 2020 [18];
- Norway: National Transport Plan 2010-2019 [19], Action Program 2010-2019 [20];
- Sweden: National Plan for the Transport System 2010-2021 [21];
- Denmark: Political Agreement on a Fixed Link Across Femern Bælt [22], Agreements on a Green Transport Policy [23];
- Fehmarnbelt: Treaty on a Fixed Link Across the Fehmarnbelt [24];
- Germany: Immediate Program Harbour Hinterland Traffic [25], Growth Program [26], Traffic Investment Report 2009 [27].

The links considered are the mainlines of the north-south corridors, see Figures 1 and 2.

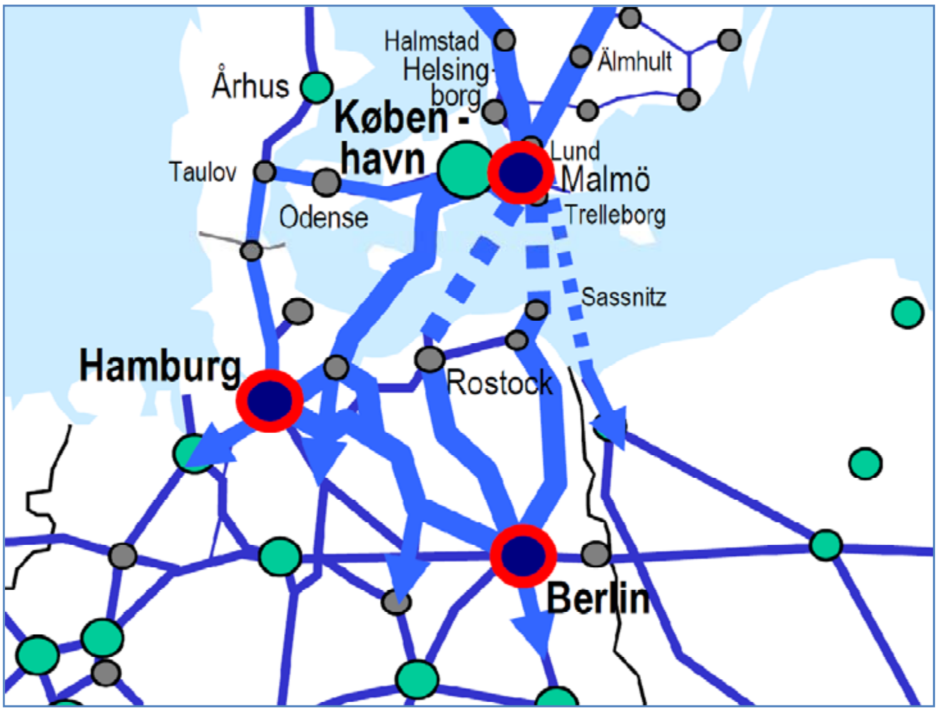

Figure 2: Cross-border railway routes of southern Scandinavia and northern Germany in 2018

5.2 Route structure and new links

The present route structure by rail and ferry is shown in Figure 1. Several new links are under construction or in the present plans:

- Norway: an additional mainline Oslo-Ski to relieve the existing line from congestion, construction to begin in 2013;
- Sweden: a tunnel through the Hallandsåsen ridge south of Halmstad, replacing an existing single track line with tight curves, to be completed in 2015;
- Denmark: a new mainline København-Køge-Ringsted to relieve the existing line København-Roskilde-Ringsted from congestion, to be completed by 2018;
- Fehmarnbelt: a fixed link, either bridge or tunnel, Rødby-Puttgarden, for railway and highway combined. Compared to the land route via Kolding, the Rødby-Puttgarden link will save some 160 km between København and Hamburg, and more for points east or south of Lübeck. The new fixed link is slated to have capacity for 48 freight trains per day in each direction, as does the land route via Kolding [28];
- Germany: a new eastern freight corridor Uelzen-Stendal-Leipzig-Regensburg on existing lines to relieve the existing corridor Uelzen-Göttingen-Würzburg-Nürnberg-Regensburg from congestion, to be implemented by 2017.

All the new links mentioned above are to be electrified and double track. The route structure and connecting lines after 2018 are marked bold in Figure 2.

5.3 Traffic control system

From the various national systems in use presently, ERTMS will be implemented throughout Europe. New lines will be fitted from the start. For existing lines, preliminary schedules indicate the following implementation schedule for ERTMS Level 2:

- Finland: schedule not announced;
- Norway: schedule not announced;
- Sweden: Hässleholm-Malmö-Öresund and Malmö-Trelleborg by 2015; Stockholm-Hallsberg-Mjölby-Hässleholm by 2019, Katrineholm-Mjölby and Kornsjø-Göteborg-Malmö by 2025, Borlänge-Frövi-Hallsberg and Gävle-Frövi by 2030 [29];
- Øresund: installation prepared, schedule not announced;
- Denmark: København-Ringsted-Rødby by 2019 and Ringsted-Kolding-Padborg by 2020;
- Germany: Padborg-Hamburg, Puttgarden-Hamburg and Hamburg-München by 2020.

5.4 Power supply

Electrification gives the ability to supply high traction power and short-time overloads, thereby enabling high speeds, heavy trains and high acceleration if dimensioned for sufficient power capacity.

With the present route structure per Figure 1, all the mainlines presently handling freight trains between Scandinavia and Germany are electrified. The power supply is shown below, together with the situation for lines connecting to the Fehmarnbelt fixed link per Figure 2:

- Finland: 25 kV, 50 Hz;
- Norway: 15 kV, 16.7 Hz;
- Sweden: 15 kV, 16.7 Hz;
- Øresund: 25 kV, 50 Hz;
- Denmark: 25 kV, 50 Hz; Ringsted-Rødby to be electrified by 2018, Køge-Næstved not electrified;
- Germany: 15 kV, 16.7 Hz; Puttgarden-Bad Schwartau to be electrified by 2018, connecting lines Lübeck-Bad Kleinen and Lübeck-Lüneburg not electrified.

5.5 Number of tracks

Double track enables trains to meet without stopping. This significantly increases corridor capacity in number of train paths per day, reduces transit times, and makes traffic less sensitive to disturbances compared to single track. Where traffic is mixed with different speeds, quadruple track is desirable, enabling trains both to meet and to pass.

The majority of mainlines handling freight trains between Scandinavia and Germany are double track. Single track sections are as follows, with plans for double tracking mentioned where adopted:

- Finland: Turku-Toijala and Turku-Kirkkonummi;
- Norway: Sandbukta-Rygge (Såstad) to be double-tracked after 2013, Haug-Onsøy to be double-tracked after 2020, Onsøy-Kornsjø;
- Sweden: Kornsjø-Öxnered, Trollhättan-Göteborg double-tracking to be completed in 2012, Båstad-Ängelholm (Hallandsåsen) double-tracking to be completed in 2015, Ängelholm-Arlöv, Borlänge-Grängesberg, Ställdalen-Frövi, Gävle-Storvik-Frövi, Hallsberg-Degerön to be double-tracked around 2021, Motala-Mjölby double-tracking to be completed in 2012, Järna-Åby, Flackarp-Arlöv to be quadruple-tracked by 2019, Lockarp-Trelleborg;
- Øresund: all double track;
- Denmark: Vamdrup-Vojens to be double-tracked by 2015, Tinglev-Padborg, Køge-Næstved, Vordingborg-Orehoved (Storstrøm bridge), Orehoved-Rødby to be double-tracked by 2018;
- Germany: Puttgarden-Fehmarnsund to be double-tracked by 2025, Fehmarnsund bridge, Fehmarnsund-Bad Schwartau to be double-tracked by 2025, Lübeck-Lüneburg, Lübeck-Bad Kleinen.

5.6 Train speed and train length

Extending the length of trains effectively raises the payload per train, regardless of the commodities carried. Extended train length can be accomplished with point improvements such as constructing longer yard tracks and sidings. Maximum freight train speed and train length (with air brakes) are generally limited by braking performance, load and required stopping distance. Characteristics are as follows:

- Finland: train length up to 925 m;
- Norway: 100 km/h for 500 m length, 90 km/h for 600 m length, 80 km/h for 700 m length with P brake, sidings being extended to 750 m or more between Oslo and Kornsjø;

- Sweden: mail trains operating at 160 km/h with disc brakes, other freight trains generally at 100 km/h, train length 730 m, sidings being extended to 750 m;
- Øresund: train length 730 m;
- Denmark: 120 km/h for 600 m length, 100 km/h for 835 m length;
- Germany: train length 750 m, plans to introduce 835 m between Padborg and Hamburg from 2011, sidings being extended to handle 750 m and 835 m trains, respectively.

The longer trains in Denmark are facilitated in part by the longer distance between distant signal and home signal, 1200 m on mainlines. In contrast, this distance is generally 1000 m on Swedish and German mainlines. To enable the increase to 835 m length between Padborg and Hamburg, braking performance is discounted and heavy wagons are precluded from long consists.

Wagons are increasingly being built for 120 km/h operation, even loaded. Denmark plans to increase the number of freight train paths at 120 km/h as a way of accommodating more freight trains daytime, slotted between faster passenger trains.

5.7 Gradient

Low gradients benefit mainly slow and heavy trains, whose low speed gives little momentum to climb a hill. A train must have the tractive effort to be able to start again if stopped at any point and under varying weather conditions, and the power output to maintain required speed. The ruling grade on each line limits the train mass that can be handled reliably by a given locomotive. High gradients should therefore be avoided.

The mainlines connecting Scandinavia and Germany generally do not exceed the gradients shown below, with exceptions noted:

- Finland: 10 ‰, except Huopalahti-Turku 12.5 ‰;
- Norway: 13 ‰, except Halden 25 ‰;
- Sweden: 12 ‰, except Halmstad-Ängelholm 12.5 ‰, Katrineholm 13.4 ‰, Öresund 12.4 ‰, Ställdalen-Frövi 17.2 ‰ (northbound climb);
- Øresund: 15.6 ‰;
- Denmark: 12.5 ‰, except Storebælt 15.2 ‰;
- Germany: 12.5 ‰.

5.8 Loading gauge and intermodal gauge

A spacious loading gauge is important for large items but also for low-to-medium density commodities which would otherwise “cube out”, i.e. reach volume limits before reaching weight limits.

For intermodal units such as trailers, the intermodal gauge defines the maximum height in cm of a 2.60 m wide trailer, measured from the 0.33 m floor height of a UIC standard pocket wagon [30]. The mainlines connecting Scandinavia and Germany accommodate the loading gauges and intermodal gauges shown below:

- Finland: KU and 420 cm on 1.1 m flat wagons;
- Norway: Oslo-Kornsjø M, U and P/C 410;
- Sweden: Kornsjø-Skälebol A and P/C 410, Skälebol-Göteborg-Halmstad C and P/C 450, Halmstad-Malmö A and P/C 410 being raised to P/C 422, Borlänge-Frövi-Hallsberg C

and P/C 450, Gävle-Storvik C and P/C 450, Storvik-Fors A, Fors-Frövi C and P/C 450, Hallsberg-Mjölby A and P/C 410 or P/C 422, Stockholm-Mjölby-Hässleholm A and P/C 432, Hässleholm-Malmö A and P/C 410 or P/C 422, Malmö-Öresund A and P/C 410 or P/C 422, Malmö-Trelleborg A and P/C 410 or P/C 422, measurements needed to verify clearances on several lines;

- Øresund: reference profile UIC GC and P/C ≈432;
- Denmark: Øresund-Kolding-Padborg G2 and P/C 410, Ringsted-Rødby G2 and P/C 400, Køge-Næstved G2, København-Køge-Ringsted not announced;
- Germany: G2 and P/C 410.

The gauges and their main dimensions are shown in Figure 3 and Table 5.

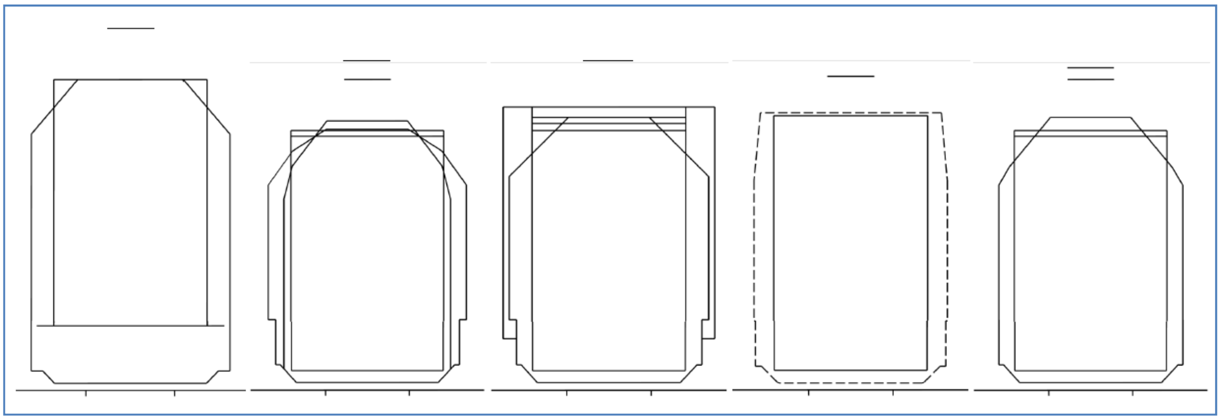

Figure 3: Loading gauges or reference profile and intermodal gauges of Finland, Norway, Sweden, Øresund and Denmark, Germany

	Finland	Norway	Sweden	Øresund	Denmark, Germany
Loading gauge	KU	M, U	C	UIC GC[1]	G2
Height (m)	5.30	4.595	4.83	4.70	4.65
Width (m)	3.40	3.40	3.60	3.29	3.15
Intermodal gauge	P/C 497	P/C 410	P/C 450	P/C ≈432	P/C 410
Height (m)	1.10+4.20	0.33+4.10	0.33+4.50	≈0.33+4.32	0.33+4.10
Width (m)	2.60	2.60	2.60	2.60	2.60

Table 5: Dimensions of the largest loading gauges or reference profile and intermodal gauges ([1] UIC GC is a reference profile, see explanation in the text) [16], [30], [31], [32], [33], [34]

In Norway new lines since 1990 are designed for the UIC GC reference profile. Sweden began in 1999 to clear existing lines for the larger loading gauge C where there is a demand for bulky freight shipments. So far, the larger C gauge is used mainly by the forest industry, having built fleets of new containers and wagons for paper and log loading which exceed the A gauge. Track spacing on double track lines varies from 4.1 m to 4.5 m. The obstacles to be cleared for the enlarged gauge are mostly platform roofs and in some cases tunnels, which must be trimmed to clear the top corners. A few lines are cleared for 3.77 m wide wagons carrying packaged lumber three wide instead of two wide.

The increased height is potentially of use also to intermodal shipments as the C gauge can accommodate highway trailers 4.50 m tall, which are common in Sweden and Norway. The increased width is benefitted from not only by freight but also by passenger trains built

3.45 m wide and seating five passengers across, with special permission even on lines with the smaller A gauge, which is 4.65 m high and 3.40 m wide.

Clearances across the Øresund link are defined by the UIC GC reference profile, which is a demarcation between the spaces available for vehicles and fixed structures, respectively. To convert this profile into a vehicle gauge or loading gauge, lateral and vertical reductions must be made for suspension condition, wheel wear, lateral play between wheel flange and railhead at 1435 mm track gauge and dynamic movements [35].

5.9 Meter load

A high meter load limit is useful for high density commodities, reducing either the number of trains needed or the length of yards and sidings necessary. Steel sheets and coils are examples of commodities benefiting from a high meter load.

The mainlines connecting Scandinavia and Germany permit the meter loads shown below:

- Finland: 8 tons/m;
- Norway: Oslo-Kornsjø 8.3 tons/m;
- Sweden: Kornsjø-Skälebol 6.4 tons/m, Skälebol-Göteborg-Halmstad 8 tons/m, Halmstad-Malmö 6.4 tons/m, Borlänge-Frövi-Hallsberg 8 tons/m, Gävle-Storvik-Frövi 8 tons/m, Hallsberg-Mjölby-Malmö 6.4 tons/m, Stockholm-Mjölby 6.4 tons/m, Malmö-Öresund 6.4 tons/m, Malmö-Trelleborg 6.4 tons/m;
- Øresund: 8 tons/m;
- Denmark: Øresund-Kolding-Padborg 8 tons/m, Ringsted-Rødby 7.2 tons/m, Køge-Næstved 7.2 tons/m, København-Køge-Ringsted not announced;
- Germany: 8 tons/m, Rendsburg bridge strengthening from 6.4 tons/m to 8 tons/m to be completed in 2013 (for simultaneous use of one track only) [36].

Existing mainlines in Sweden are gradually being upgraded to 8 tons/m where there is a demand for heavy freight transport. New lines and replaced bridges are being planned for 10 tons/m.

5.10 Axle load

A high axle load limit is useful for almost all commodities, with the number of axles per wagon depending on the density of the commodity. It lowers transportation cost by enabling a higher load per wagon.

The mainlines connecting Scandinavia and Germany permit the axle loads shown below:

- Finland: Tampere-Toijala 25 tons, Toijala-Turku 22.5 tons, Helsinki-Turku 22.5 tons;
- Norway: Oslo-Kornsjø 22.5 tons, strengthening to 25 tons ongoing [11];
- Sweden: Kornsjø-Skälebol 22.5 tons, Skälebol-Göteborg-Halmstad 25 tons, Halmstad-Malmö 22.5 tons, Borlänge-Frövi-Hallsberg 25 tons, Gävle-Storvik-Frövi 25 tons, Hallsberg-Mjölby-Malmö 22.5 tons, Stockholm-Mjölby 22.5 tons, Malmö-Öresund 22.5 tons, Malmö-Trelleborg 22.5 tons;
- Øresund: 22.5 tons;
- Denmark: 22.5 tons, København-Køge-Ringsted not announced;

- Germany: 22.5 tons, Rendsburg bridge strengthening from 20 tons to 22.5 tons to be completed in 2013 [36], Rostock-Berlin strengthening from 22.5 tons to 25 tons to be completed in 2013 [37].

Existing mainlines in Finland, southeastern Norway and Sweden are gradually being upgraded to 25 tons axle load where there is a demand for heavy freight transport. New lines in Sweden are being planned for 30 tons.

In Germany, Rostock-Berlin-Eisenhüttenstadt will be the second line upgraded for 25 tons. (The first is Hamburg-Uelzen-Lehrte-Salzgitter.)

6 REMAINING BOTTLENECKS AND WEAK LINKS

Although the existing capacity bottlenecks are being addressed by ongoing improvement programs, new bottlenecks will occur as transport demand increases. Significant discrepancies in technical standards exist, which are not yet addressed in infrastructure or operating plans.

In particular, the following bottlenecks and weak links are identified, which hamper the efficient through operation of whole trains or even individual wagonloads in the corridor:

- Finland: partial single track, partially low axle load, no through operation of trains due to wider track gauge.
- Norway: extensive single track, short train length, steep gradient at Halden, low and tapered loading gauge, low intermodal gauge.
- Sweden: partial single track, short train length, partially low and tapered loading gauge, partially low intermodal gauge, partially low meter load, partially low axle load.
- Øresund: short train length, steep gradient, low and narrow loading gauge, low intermodal gauge, low axle load.
- Denmark: steep gradient at Storebælt, low, narrow and tapered loading gauge, low intermodal gauge for transit purposes, low meter load on lines connecting Fehmarnbelt, low axle load.
- Germany: non-electrified and single track from Lübeck southward and eastward, no connecting track at Bad Kleinen, narrow and tapered loading gauge, low intermodal gauge for transit purposes (Scandinavia-France), low axle load on most lines.

7 CONCLUSIONS AND RECOMMENDATIONS

The market share of freight trains in the corridor between Scandinavia and Germany is significantly less than those of trucks and ships. Thus, there is potential for significantly increased transport volumes by train, if the train services are made more attractive to the shipper. The measures outlined here would aim to raise system capacity as well as to lower costs.

7.1 Improving network capacity and quality

Capacity constraints in the form of single track sections exist on several of the lines in the Scandinavian-German corridor. It would be desirable to accelerate track duplication to improve both capacity and fluidity on these lines. In the short term, construction of additional sidings would add capacity and flexibility, particularly near Kornsjø and Ängelholm-Arlöv.

To minimise bottlenecks in northern Germany, existing lines connecting the Fehmarnbelt link to the main north-south corridors through Lüneburg and via Bad Kleinen through Ludwigslust need to be electrified to enable through operation.

Large differences in speed reduce capacity, creating a need for additional sidings even on double track. Additional freight train paths for 120 km/h can be established during daytime in areas where passenger traffic dominates. The number of wagons approved for 120 km/h operation, empty or loaded, is growing steadily, making this feasible.

7.2 Adapting technical standards

Significant discrepancies of technical standards still exist between the various national railway networks.

For new construction and upgrading of infrastructure, the opportunity to apply bold, forward-looking standards should be seized. These standards should be as high as, or higher than, the highest existing or planned standards on the connecting corridors and networks.

Increasing train lengths to 835 m appears feasible in the short term between the gateways of southern Sweden and its major marshalling yards: Malmö, Hallsberg, Sävenäs (Göteborg) and Borlänge as well as Stockholm. This would raise the capacity of run-through trains. The necessary investment could be kept to a minimum, particularly if the longer trains were operated at night, with few fast trains needing to pass and therefore moderate need for extended sidings on the double track lines. In the longer term, increasing train lengths to approximately 1500 m (two standard trains coupled) on the main corridors of Germany and Scandinavia appears feasible.

Establishing a large, rectangular loading gauge for new construction and upgrading of existing railway lines. Considering the normal catenary heights of 5.3 to 5.5 m in Denmark and Germany, a height matching the Swedish C loading gauge at 4.83 m appears feasible. A corridor cleared for intermodal loads up to this height between Sweden and France through Denmark and western Germany would be able to transport trucks of 4.5 m height, as are common in Norway, Sweden, France and Britain.

Building foundations as well as track for 25 tons axle load or heavier for new construction and upgrading of existing railway lines. 25 tons or heavier is already being applied on portions of several national railway networks in Europe, including those of Belgium, Finland, Germany, Norway, Slovakia, Sweden and the United Kingdom.

Raising meter loads to 8 tons/m between the gateways of southern Sweden and connecting lines at Halmstad and Hallsberg.

The 25 ‰ grade at Halden, being twice as steep as other grades on the Oslo-Göteborg line, restricts train mass on this line. Easing this grade to 12 ‰ would enable heavier trains or eliminate the need for multiple locomotives, particularly as sidings are being extended on this line. For reference, similar standards have also been proposed by the Ferrmed Association [38].

7.3 Proposed standard for new links, including Fehmarnbelt and connections

The planned Fehmarnbelt link and its connecting lines should generally match or surpass the highest of German, Danish and southern Swedish standards:

- Maximum gradient 12 ‰. (Although Fehmarnbelt is connected in series with the existing Öresund link which has 15.6 ‰ gradient, a new, parallel northern Öresund link is already being proposed.).
- Length of sidings for 1500 m trains plus a portion of the stopping distance, e.g. 1500 m + 200 m = 1700 m.
- Loading gauge matching the Swedish C profile of 4.83 m × 3.6 m, or reduced to 4.83 m × 3.4 m, with full width at the top.
- Axle load 25 tons or more.
- Meter load 8 tons/m or more.

In summary, much is being done to improve capacity and quality and much more remains to be done, not all of it requiring large investment.

8 FUTURE WORK

The technical standard of each link of the rail corridor between Scandinavia and Germany will be plotted on maps to visualise the distribution of the various levels of standard.

Freight flows will be modelled by computer simulation to assess capacity and capacity utilisation for various scenarios, identify capacity bottlenecks and study the effect of possible remedial measures.

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DEFINITION OF THE FLAVIA LOGISTICS CORRIDOR (CENTRAL/SOUTH-EAST EUROPE) AND THE INTERNATIONAL MARKET

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ABSTRACT

The idea of the project FLAVIA is to establish intermodal cooperation and to develop the logistics corridor from Central to South-East Europe and Black Sea countries. Intermodal freight transport connections in FLAVIA corridor are insufficient but urgently needed for more and efficient import and export. A lot of potential trade partners as well as large amounts of natural resources, like oil, copper and gas, exist in the Black Sea area and beyond along the TRACEA (Transport Corridor Europe-Caucasus-Asia).

The FLAVIA logistics corridor project involves partners from Austria, the Czech Republic, Germany, Hungary, Poland, Romania and Slovakia. Improving logistics flows among the involved regions, the reduction of barriers in the intermodal logistics flows will result in a stronger integration of the new member of the EU. In this connection FLAVIA project partners have started analysis of demographic and economic development in the logistics corridor as well as needs of logistics market players in the involved regions. This is the first step to identify problems and barriers in intermodal freight transport, e.g. why modal split of rail and inland waterway dropped down despite of increased volumes, how arise big delays of freight trains at border crossings, what mental barriers of market players exist against intermodal transport, etc.

This paper gives an overview of the demographic and economic development of the FLAVIA logistics corridor. The results serve as a basis for further project actions and show differences between involved countries. Each FLAVIA country has its own specifics which must be followed, but the main goal of this article is to show some common problems or weak points which must be retrieved for advancement of freight transport and logistics chains.

This article shows that FLAVIA logistics corridor has demographic and economic potential for development of industry and accompanied services, e.g. transport and logistics. Therefore, the next steps in FLAVIA project will make the most of pre-feasibility studies and best practice first and foremost oriented on a better rail connectivity. All those activities will be undertaken to promote economic development, trade and growth with simultaneous reduction of environmental impacts through the intensive support of intermodal rail and inland waterway transport ways. Additionally, establishing an efficient Trans-European Transport Network (TEN-T) is a key element for competitiveness and employment in Europe. FLAVIA will support and improve intermodal logistics flows and channels, especially along the TEN-T corridors IV (Dresden-Prague-Bratislava/Vienna-Budapest-Arad) and VII (Waterway Danube).

Finally, the territorial cohesion of the involved regions should be strengthened by a reduction of organizational, administrative and technical barriers of integrated logistics chains and a further

development of logistics and trade relations between Central and South-East Europe and beyond to the Black Sea countries.

1 INTRODUCTION

The Project FLAVIA covers seven countries from Germany in the Northwest to Romania in the Southeast. This article gives an overview of the demographic and economic development of the corridor. The results shall identify the status-quo of the corridor. They will also show differences between the involved countries. For that reason demographic and economic indicators are described and compared. Each country has its own specifics which must be followed, but the main output of this article is to present some common problems or weak points which must be retrieved for advancement of freight transport and logistics chains.

First of all some common indicators have been determined. The most reliable source is the website of Eurostat, which provides statistic data for entire Europe. Secondly the available data has been evaluated. By comparing the countries indicators' specific results have been drawn regarding population, economy as well as trade and transport flows within the FLAVIA corridor. Finally conclusions have been deduced from the available results.

The analysis shows that the FLAVIA corridor has demographic and economic potential for development of industry, transport and logistics. Most of the involved countries have developed very dynamically in the past ten years. The economical crisis affects the corridor but not that strong as in other countries in the EU.

Also flaws and country specific differences within the corridor have been detected. The population within the FLAVIA corridor will decrease in the next years. Additionally a high rate of emigration will intensify this process. Another demographic problem will be the change of the age structure in favour of older people (>65 years). Another major problem is the state budget deficit. No country possesses a balanced budget.

The share of railroad transport in the Western part of the corridor is much higher than in the Eastern part. The missing link of Romania to the other countries has to be analysed. Reasons of that disproportion must be found and despatched in further actions.

FLAVIA as one of the projects in Central Europe wants to improve different aspects of transport processes. The improvements are oriented on greener logistics, lower transport costs, higher energy utilization and many others.

FLAVIA benefits will be in better information of carriers how to make their business more efficient and to reduce trade and transport barriers. Keeping this in mind the following identification of major transport flows and subsequently measures to improve these flows will be important.

The promotion of FLAVIA results can benefit from such basic analysis, too. This article presents differences on the field of demographic and economic development and will be the basis for future infrastructural or economical recommendations.

2 ANALYSIS OF THE FLAVIA CORRIDOR

The FLAVIA corridor covers an area of 120 000 square kilometres. More than 175 mil people live in the involved countries (Germany, Poland, Czech Republic, Slovakia, Austria, Hungary and Romania). This implies a share of app. 35 % of the entire EU27. All FLAVIA countries are EU members and three of them (Germany, Austria and Slovakia) are in Euro area as well.

2.1 Population

The amount of people in FLAVIA countries decreases slightly, except Austria. The reason of the decline is due to a fertility rate which is around 1.4 children per one woman. This means one couple has on the average less than 2 children. Table 1 shows the development of the population in the FLAVIA countries and Figure 1 depicts a visualization of the aforementioned data.

Country	2010	2020	2060
Germany	81 799 571	81 474 59	70 759 309
Czech Republic	10 506 813	10 543 351	9 513 808
Poland	38 136 000	37 959 838	31 138 967
Austria	8 363 040	8 723 363	9 037 295
Slovakia	5 424 925	5 432 265	4 547 624
Hungary	10 007 000	9 892 967	8 716 677
Romania	21 462 186	20 833 786	16 921 425
TOTAL	**175 699 535**	**174 860 168**	**150 635 105**

Table 1: Development of population in FLAVIA corridor countries [1]

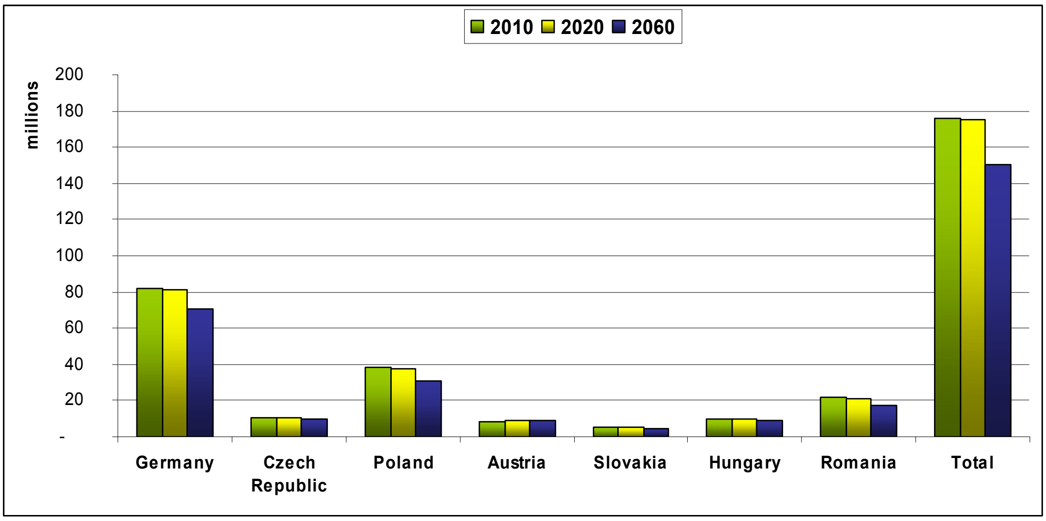

Figure 1: Development of population in FLAVIA corridor countries [1]

The second important factor which influences the people volume is the rate between immigration and emigration. The volumes of migratory people are presented in Table 2. In total the volume of immigrated people is higher than emigrated. Only the migration balance of Germany and Poland indicates a negative amount. The rates of unemployment are depicted too. First one is the actual rate of unemployed people. The second one shows how many people are unemployed for a long term. So the real unemployment results in the difference between those two values.

Country	Rate of unemployment	Long term unemployment	Immigration [people]	Emigration [people]	Fertility rate
Germany	7.5	3.4	682 146	737 889	1.38
Czech Republic	8,7	2.0	77 817	6 027	1.50
Poland	8.2	2.5	47 880	74 338	1.51
Austria	4.8	1.0	110 074	75 638	1.39
Slovakia	12.0	6.5	17 820	4 857	1.43
Hungary	10.0	4.2	37 521	4 821	1.37
Romania	6.9	2.2	10 030	8 739	1.32
FLAVIA			**983 288**	**912 309**	

Table 2: Demographic overview – FLAVIA (year 2010) [1]

One of the most widely known demographic indicators is the age structure, especially how it changes in time. For comparison of the FLAVIA countries the years 1998 and 2009 were chosen. By comparing the values for each country, there can be seen an effect known as aging of population. Less working people will have to work on more elderly people. This will result in higher claims to the state economies and social systems. Larger problems will have countries without pension reform (Czech Republic, Slovakia and Hungary). The volume of people in active age (15-64) is 1 % higher in the FLAVIA countries than in the entire EU27.

Country	Year	0-14	15-24	25-49	50-64	>64	15-64
Germany	**1998**	16.0	11.0	38.4	18.8	15.8	68.2
	2009	13.6	11.4	35.7	18.9	20.4	66.0
Czech Republic	**1998**	17.4	16.4	35.6	17.0	13.6	69.0
	2009	14.1	12.8	37.1	21.0	15.0	70.9
Poland	**1998**	21.1	16.4	36.7	14.1	11.7	67.2
	2009	15.3	14.9	36.1	20.2	13.5	71.2
Austria	**1998**	17.5	12.1	38.4	16.7	15.3	67.2
	2009	15.1	12.2	37.2	18.0	17.5	67.4
Slovakia	**1998**	21.0	17.2	36.6	13.9	11.3	67.7
	2009	15.4	15.0	38.2	19.2	12.2	72.4
Hungary	**1998**	17.4	15.5	35.2	17.2	14.7	67.9
	2009	14.9	12.6	35.7	20.5	16.3	68.8
Romania	**1998**	19.2	16.8	35.4	15.8	12.8	68.0
	2009	15.2	14.4	37.0	18.6	14.8	70.0
EU27	**1998**	17.7	13.5	36.8	16.8	15.2	67.1
	2009	15.7	12.5	36.2	18.6	17.0	67.3
FLAVIA	**1998**	17.9	13.6	37.3	17.0	14.3	67.8
	2009	14.4	12.8	36.2	19.3	17.3	68.3

Table 3: Age structure [%] – FLAVIA (years 1998 and 2009) [1]

The people volume of FLAVIA countries will decrease until the year 2060 by 15 %. This circumstance varies from the global development which expects an increase of more than 50 % until the year 2060. The globalization entails higher migration of people from developing countries in Africa and Asia. That might imply an impact on trade, transport, industry and consumption of the FLAVIA countries.

The second threat which follows the first one is the aging process of the population. From Table 2 it stands to reason that the share of people over 65 years has grown for past ten years by nearly 2 % in EU27. The share of people under 15 years also decreased about 2 %. That process is similar in the FLAVIA countries, but the share range is wider. There is a higher decrease of age group under 15 and a higher increase of people over 65 years.

2.2 Economy

The economic development of nearly the whole FLAVIA corridor is to a great extent influenced by global economic situation. Just Germany and Austria are strong economies which are drawing economy of EU. Just three countries of FLAVIA corridor are in Euro Area. The other ones still have their own national currencies.

Their exchange rates are closely related to Euro (€) and American dollar (USD). A big threat for most of the FLAVIA countries is the share of the budget deficit of the GDP. The roots of those deficits are usually in Economic crisis, because we can observe large rates of growth in the past years. Just Hungary registered stagnation. But Hungary has rather deep economic problems.

Table 4 shows the share of deficit on state budget in % of the FLAVIA countries. In 2007 and 2008 the average of the state budget deficit in the FLAVIA countries was higher than in EU27. This situation changed in 2009. The FLAVIA countries had less deficit than the whole EU27. This corresponds with the above remarked ranking of countries with highest resistance to economic crisis. Three from four of the best ranked countries are from the FLAVIA corridor.

Country		2009	2008	2007
Austria	%	-3.4	-0.4	-0.4
Czech Republic	%	-5.9	-2.7	-0.7
Germany	%	-3.3	0.0	+0.2
Hungary	%	-4.0	-3.8	-5.0
Poland	%	-7.1	-3.7	-1.9
Romania	%	-8.3	-5.4	-2.5
Slovakia	%	-6.8	-2.3	-1.9
EU27	%	-6.8	-2.3	-0.8
FLAVIA	%	-5.5	-2.6	-1.7

Table 4: Share of state budget deficit on GDP – FLAVIA [1]

Most of the FLAVIA countries are post-communistic; therefore their economic level is lower than in Western Europe. On the other hand in past ten years their economy developed more dynamic than in Western Europe (Table 5). The GDP of all FLAVIA countries accounts for 3 403 477 bn. €. This implies a share of 28.84 % of the EU27, but more than 70 % is produced in Germany. All countries have a state budget deficit. Its range goes from 3.5 to 80 mil. €. The right side of the table shows that three FLAVIA countries have a significant export deficit and three of them have a significant surplus. Slovakia has nearly an even balance.

Country	GDP in current prices [bn. €]	GDP growth in %	State budget deficit (-), surplus (+)	Export	Import	Balance
			[bn. €]			
Germany	2 406 740	16.9	-79 410	803 899	668 104	135 795
Czech Republic	137 402	85.6	- 8 133	81 213	75 267	5 946
Poland	310 360	229.7	-22 120	96 396	105 123	-8 727
Austria	276 649	67.0	-9 496	98 650	102 795	-4 145
Slovakia	63 332	49.3	-4 289	40 115	39 569	0 546
Hungary	93 364	42.2	-3 765	60 036	56 034	4 002
Romania	115 627	33.0	-9 620	29 116	38 891	-9 775
EU27	11 799 142					

Table 5: Economic indicators – FLAVIA [1]

The economic development of the whole corridor is affected by global economic crisis, but in less extent than expected. National economies are recovering and the revival of trade supports the transport. A strong point for the FLAVIA countries is a well-balanced proportion between industrial and agricultural sector. The Locations of the main economic centres across the corridor can be seen in Figure 2.

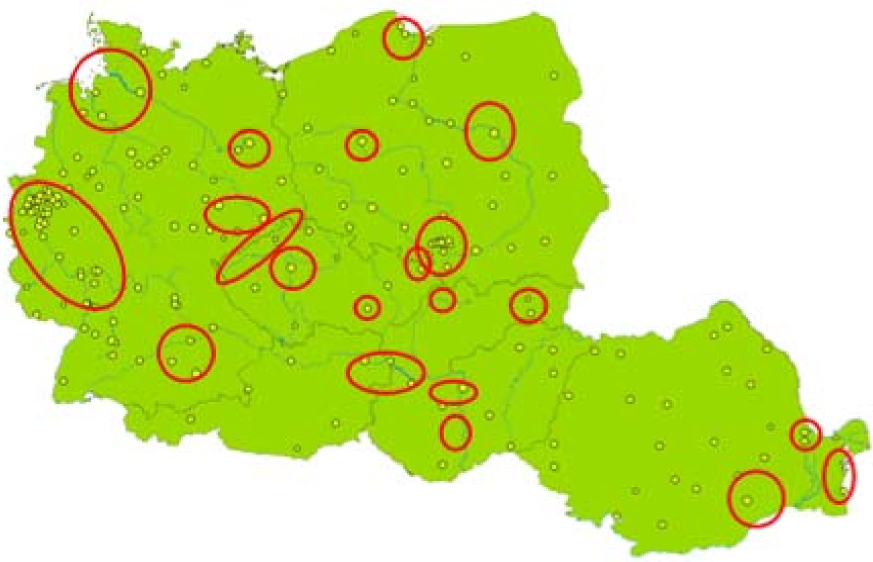

Figure 2: Economic centres along the FLAVIA corridor [1]

Nevertheless threats exist, too. They vest in increasing of state deficits and mainly their share on GDP. Table 4 shows a large growth of that share between years 2008 and 2009. Public administrations have to consolidate public finances as soon as possible. Economy is also threatened by an issue mentioned in previous chapter - the aging process.

It has charge on public finances, because lower volume of working population endows state budget paying social and health insurance or personal income tax. That expectable loss of incomes needs conceptual solution and public finances reform. Project FLAVIA has to keep this fact in mind.

2.3 Trade and Transport

All countries involved in FLAVIA except Romania are part of Schengen Area (SA). This agreement signed in Luxembourg enables travelling inside the area without internal border controls. Romania presented the Declaration of Readiness for the Schengen evaluation. Expected accede to SA is the year 2011. SA means a big advantage for haulers because they do not have to stop at each border for custom inspection.

The neighbourhood destines the FLAVIA countries for a close cooperation on many fields. Trade, transport and logistics belong to it too. Movement of goods within the EU27 uses in particular road, rail, inland waterway transport and short sea shipping. The following tables show the value of its contribution to the total transport capacity in the FLAVIA countries (only land based modes). The transport flows in tons between the FLAVIA countries per transport mode is given in Table 6. It can be seen that the largest share of the transportation is in road transport especially in domestic relations.

[mil tons]		CZ	DE	HU	AT	PL	RO	SK
CZ	Road	398,1	8,8	0,9	1,4	2,7	0,3	3,8
	Rail	45,9	3,6	0,2	0,3	7,0	0,0	9,9
	IWW	0,4	0,3	-	-	0,0	0,0	0,0
DE	Road	10,7	2928,2	2,4	13,6	11,8	2,7	1,9
	Rail	4,3	217,9	1,1	6,3	8,2	0,0	1,1
	IWW	0,4	57,2	0,6	0,5	1,8	0,0	0,3
HU	Road	1,0	2,5	239,5	1,6	1,1	0,9	2,2
	Rail	1,0	1,3	12,1	2,1	0,5	1,1	1,2
	IWW	-	0,1	0,1	0,4	-	0,2	0,0
AT	Road	3,1	20,2	1,8	316,1	0,7	0,4	0,7
	Rail	4,3	10,0	2,6	30,5	3,4	0,1	1,3
	IWW	-	0,7	0,5	1,1	-	0,5	1,1
PL	Road	2,6	12,7	0,9	0,6	823,0	0,2	1,2
	Rail	3,3	2,7	0,3	0,3	227,7	0,1	1,9
	IWW	-	0,2	-	-	4,5	-	-
RO	Road	0,5	2,4	1,2	0,5	0,3	317,3	0,2
	Rail	0,3	0,2	2,0	0,4	0,5	53,2	0,4
	IWW	-	0,0	0,5	0,1	-	23,6	0,0
SK	Road	4,0	2,0	1,3	0,8	1,4	0,1	161,4
	Rail	3,9	0,3	0,5	0,2	1,9	0,1	7,5
	IWW	-	0,0	0,0	0,2	-	0,0	0,1

Table 6: Volumes of transport between FLAVIA countries [1]

Table 7 and 8 show the share of loaded and unloaded goods within the FLAVIA countries. The tables present the shares of each mode of transport to domestic transportation, transportation to the FLAVIA corridor countries and to other countries of the EU27 outside the FLAVIA corridor. Domestic road and rail transport dominates in all countries. Foreign transport flows within the EU are carried out by road transport to a minor extend. Inland waterway transport depends on whether there is a suitable way to allow regular water transportation. For example, Slovakia and Hungary use the ideal connection of Danube waterway for foreign trade. Germany has an extensive network of waterways, which is used mainly for domestic transport and transport outside of the FLAVIA countries.

Load [%]		CZ	DE	HU	AT	PL	RO	SK
Domestic	Road	94%	94%	95%	91%	97%	97%	93%
	Rail	72%	84%	57%	63%	91%	95%	31%
	IWW	52%	51%	3%	46%	71%	95%	6%
FLAVIA	Road	5%	2%	3%	5%	2%	1%	6%
	Rail	27%	7%	31%	20%	9%	3%	65%
	IWW	44%	2%	70%	45%	28%	3%	87%
Outside FLAVIA	Road	1%	4%	2%	4%	1%	2%	1%
	Rail	2%	9%	12%	18%	1%	2%	4%
	IWW	4%	47%	27%	9%	1%	2%	8%

Table 7: Share of load in FLAVIA countries [1]

Table 7 and 8 indicate that the majority of transports are domestic. By neglecting those transports it can be ascertained that the trade between FLAVIA countries is twice or more higher than to the rest of EU27. There are exceptions of course, which are caused by local specifics, e.g. strong position of Danube River in Romania or existence of major seaports in Northern Germany.

Unload [%]		CZ	DE	HU	AT	PL	RO	SK
Domestic	Road	94%	95%	95%	90%	97%	97%	94%
	Rail	71%	68%	80%	59%	51%	96%	92%
	IWW	53%	37%	8%	24%	95%	96%	28%
FLAVIA	Road	4%	1%	4%	8%	2%	2%	6%
	Rail	27%	31%	8%	35%	37%	4%	7%
	IWW	43%	2%	68%	58%	5%	3%	59%
Outside FLAVIA	Road	2%	4%	1%	3%	1%	2%	1%
	Rail	2%	1%	12%	6%	12%	1%	1%
	IWW	3%	61%	24%	18%	0%	1%	13%

Table 8: Share of unload in FLAVIA countries [1]

3 RESULTS AND DISCUSSION

The presented analysis shows that the population in FLAVIA corridor will decrease. Until the year 2060 the population will decline about 14.3 %. This implies a total loss of 25 million people during the next 50 years.

That is a major threat, because this will result in missing junior and qualified employees in the future. This circumstance might lead to a reduced economical competitiveness of the regions in the FLAVIA corridor. A possible solution can be the easier integration of well-educated immigrants in the FLAVIA countries.

The age structure will also change in favour of older people. That affects and will affect the countries social systems to a large extent. As one consequence the retirement age should be discussed intensively in the FLAVIA countries under the light of the changing society.

The changing age structure also might change the demand of the consumers, because older people will demand different goods than younger people. For that reason new health care products and services have better chances in the market.

FLAVIA countries were gaining more than 70 thousand people by emigration in 2008. Germany and Poland are the only ones who lose population among the FLAVIA countries. Said countries have to find a suitable solution how to change that state. Especially outbound migration of high educated people is a big threat. Two fields of activities will arise: attracting qualified employees from abroad and keeping young professionals in the country. This is a new challenge for policy-makers.

All FLAVIA countries have a state budget deficit, which is not unusual in the world. But long term debt is slowing the economy and at the end it might lead to a situation similar to the one in Greece. National finances must be well balanced to reach sustainability. New debts and the resulting interest rates will disadvantage succeeding generations. Otherwise the economies of most of the FLAVIA countries have grown dynamically in the past 10 years and have come through the recent crisis partly well.

The economic centres of the FLAVIA corridor (Figure 2) are distributed evenly, just between Hungary and Romania a big gap has been detected due to traditional settlement schemes.

Additionally all FLAVIA countries have a big share of road transport. On short distances road transport depicts the most suitable solution, but on longer distances railroad and inland waterway transport are competitive enough. Low average speed of cargo trains e.g. in Slovakia, Hungary and Romania have some potentials to strength this mode of transport. Especially goods in ISO containers are very suitable for modal shift, because it is not important what kind of goods are transported. The transport unit is always the same.

Inland waterway transport is very cost-efficient, but it needs high volumes of goods and a suitable location of origins and destinations concerning the infrastructure.

4 CONCLUSIONS

In the last years new European projects have had a very important role in finding suitable solutions for advanced logistics. Haulers, carriers and forwarders must be educated in existing possibilities to make their business more efficient. Higher education of Middle European hauliers and forwarders about intermodal transport solutions and the role of the FLAVIA corridor including the Black Sea ports will increase importance of the whole corridor. The project FLAVIA will support the process of knowledge transfer and better utilisation of railroad and inland waterway infrastructure to cover new traffic flows along the corridor.

The FLAVIA corridor might be a follow of the TRACECA corridor from China to the Black Sea and vice versa. FLAVIA and TRACECA could be a new opportunity for transport of goods to and from China to Europe faster than nowadays. That opportunity entails a positive synergic effect in demographic and economic development.

Regarding the products the countries exchange potentials for intermodal transport can be derived. Vehicle components, semi-finished products or metal products are well suitable for container transports. One task will be to find out which potentials exist and which volumes are realistic for shifting to intermodal transport.

The most important transport flows are in direction East – West. Large volumes of goods are transported from North Germanic Sea ports to terminals in Czech Republic, Slovakia and Hungary. Lack of flows exists to Romania. There is a chance for development of that corridor as well as for cross delivery of goods to Central Europe from Black Sea ports.

Higher accessibility of the Eastern parts of the FLAVIA corridor will establish new economic occasions which will be pretentious to transport and logistics services. Better transport connections will attract investors, customers and new job opportunities.

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RAIL FREIGHT CORRIDORS AS A CONCEPT FACILITATING EAST-WEST TRANSPORT LINKS IN THE FUTURE

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ABSTRACT

In the context of sustainable transport development and EU policy development in the last two decades railway transport has the green light to intensive revitalization of this transport mode. It requires the wide actions aiming at improving the performance, competitiveness and capacity of railways.

In the paper the authors identify the need for improved rail connections between Eastern and Western Europe. The background for the assessment is the evaluation of cargo flows based on the available statistics. Then also EU legislation and programming documents aiming at promoting and better adjustment railways to current economies are subject of the analysis. Some new initiatives as a proposal for a regulation on the creation of a European network for a competitive rail freight is taken into consideration. The European Commission has already proposed the creation of a European Rail Freight Oriented Network based on freight corridors. The corridor approach was recognised by experience (ERTMS corridors) and expert judgement as the suitable foundation for a Rail Freight Oriented Network. By increasing the overall quality, efficiency and capacity of intermodal rail freight transport, the competitiveness of the international rail freight transport on the corridor can increase considerably. This goes along with the EU policy for rail freight transport and will be beneficial to the economy in general. As the Commission stated, the creation of the corridor should approximately follow the idea of Trans-European Rail Freight Freeways (TERFF) with focus on organisational measures rather than investments to railway infrastructure. Attention must be paid also to possible interconnection with other rail freight corridors along the route.

The special attention in the paper is put on rail freight corridors linking Eastern Europe to the West, especially the concept of two corridors: from the Netherlands through Germany to Poland and from Germany to the Czech Republic. Existing programmes, policy proposals how to develop these corridors, as well as reports describing determinants of selection of paths and terminals are reviewed. Additionally implementing barriers are identified and analysed. A lot of determinants can influence development of the concept of the corridor, e.g. prices for the use of rail infrastructure, capacity allocation, bottlenecks on the infrastructure, availability of necessary facilities, cross-border operation of engines and train-drivers, safety certification. Different types of barriers are grouped and taken into consideration in the paper. Additionally some action plans to overcome the barriers are suggested and summarized.

It is interesting to analyse what the impact of the corridors would be for the transport in general in the future. Some studies on the subject have already been conducted. In the paper authors try to resume and conclude the reports and answer the question how corridors will improve transport links between Eastern and Western Europe in the future.

1 INTRODUCTION

The objective of the paper is to show to what extent rail freight corridors could facilitate East-West transport links in the future. Freight flows between Eastern and Western Europe during recent years seem to be more and more important. This is a result of the EU enlargement as well as increasing intensity of the foreign trade with Euro-Asia. In the EU the objective of sustainable transport development has been realised since 90s of XX century but still the market share of rail transport has been steadily declining over the years. In 2005 in the EU-25 it reached its minimum - only 10%. Although the performance is now slightly increasing the trend is still not very strong.

Therefore the concept of freight rail corridors could be on one side the remedy to solve the problems of East-West transport links and on the other side it would influence the realisation of sustainable transport policies positively. Moreover, freight corridors could also serve as catalysts for an integrated European distribution system.

Additionally another aspect of corridors development should be noticed. One of the reasons of the low market share of railway transport is the fragmentation of the European rail markets and networks. The corridors development policy can be successful only if the better coordination between member states and infrastructure managers will be ensured.

Another problem of nowadays railways is the lack of investment. Consequently rail freight must recover its lost efficiently and effectiveness through the gradual development of a dedicated network. Strong political support and financial procedures within corridors development would also help in this area. Corridors could additionally improve railways service quality especially through reducing journey time, delays at the borders etc.

2 STATISTICAL NOTICE

In the past few years, freight transport has been constantly increasing in the European Union, at a yearly average of 2.8% in the 1995-2005 decade. Indeed, thanks to advances in transport technology, costs have considerably decreased, thus allowing higher trade volumes. In addition to this, the recent enlargements of the EU and its internal market have resulted in higher West/East trade volumes. Against such overall increase in freight transport, the share of rail freight transport has been declining. In 2005, only 10% of freight cargos were transported by rail in EU-25 Member States. Yet, such figures vary widely across the EU. Some countries have a higher share of rail transport, while in some other ones rail is insignificant in the national freight transport system [1].

Considering the various stages of development in different parts of Europe, this analysis is structured around a four-area classification, so that the results could be applied on a large scale. The first cross-border area is EU-27 to/from Switzerland and Norway. Here, the cross-border transport markets are well-developed and there are no major issues in terms of interoperability. The second area is EU-27 connections from Baltic States to Eastern Europe. In this case, there are no issues in terms of interoperability due to the existing gauge system as Finland, Estonia, Latvia and Lithuania in the EU and Russia and Ukraine all use the 1,520 mm gauge. The third area includes the border between EU-27 and Ukraine, Belarus and Moldova. Here, the transfer from a 1,435 mm gauge to the 1,520 mm gauge results in several interoperability issues. The fourth area includes all the EU-27 cross-border connections with the Balkan region and Turkey, which use the 1,435 mm gauge. Here, there are several issues in terms of interoperability, generated by the characteristics of the region, and not by the gauge system [2].

Accordingly to the data provided by TRANS-TOOLS and Eurostat in the first area, cross-border traffic recorded a volume of 21,976 thousand tonnes in 2001, 25,506 thousand tonnes in 2005 and 25,855 thousand tonnes in 2007, which represents an 18% increase in freight volumes. The second area recorded a traffic volume of 82.803 thousand tonnes in 2001, 85,647 thousand tonnes in 2005 and only 77,280 thousand tonnes in 2007, resulting in a drop of 8% in freight volumes. The third area recorded a traffic volume of 31,500 thousand tonnes in 2001, 28,390 thousand tonnes in 2005 and 33,874 thousand tonnes in 2007, which led to a 7% increase in the freight volumes carried. The fourth area recorded a traffic volume of 1,495 thousand tonnes in 2001, 10,001 thousand tonnes in 2005 and 11,193 thousand tonnes in 2007, resulting in an increase of 649%. The freight volumes were recorded during 2001-2007 between EU-27 and non-EU countries. In 2001, up to 137,824 thousand tonnes of freight were carried; in 2005 – 149,544 thousand tonnes. 2007 brought a slight decrease to 148,202 thousand tonnes, resulting in an 8% increase. The data furthermore indicates that while rail mode share will remain similar in the future some changes to the above picture in main rail corridors might be expected till 2020 (see Figure 1).

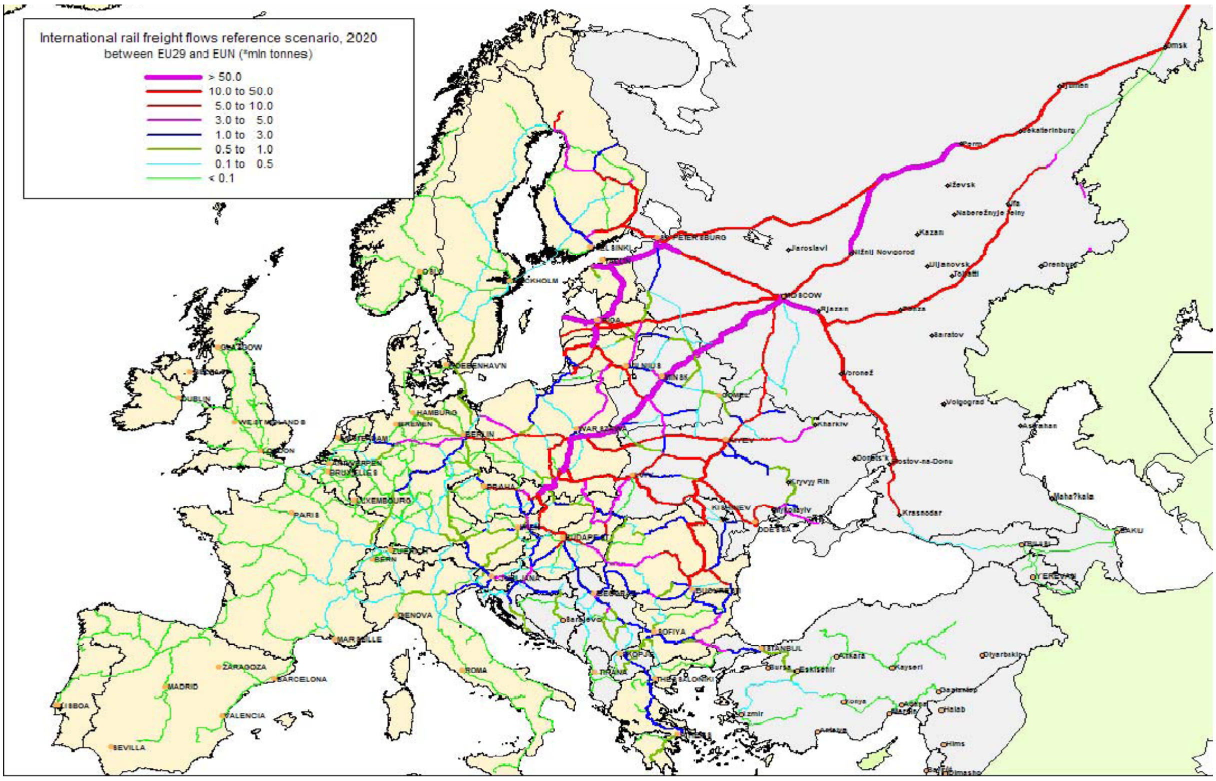

Figure 1: Freight flows in Europe till 2020 [8]

3 WHY ARE RAILWAY CORRIDORS IMPORTANT?

The vision for the future of freight rail transport in 2020, as it is stated in the Strategic Rail Research Agenda 2020 by European Rail Research Advisory Council in May 2007 can be summarized as follows:

"A Europe, able to breathe again, that has succeeded in avoiding a complete standstill on its road network and has prevented irreparable damage to the environment through the

broad recovery of modal equilibrium for freight traffic. Freight shuttles, on a Trans-European Freight Network, predominantly dedicated to freight traffic, are serving the economy with longer and heavier trains running on time as an integral part of the loaders' logistical chain. They link industrial platforms, supply combined road/rail or intermodal services for maritime units and provide transport for finished products to the distribution platforms. The use of high-grade technology for sensors, information techniques and telecommunications means that goods are monitored and controlled continuously and the condition of payloads are checked over the entire length of the transport section. The railway mode plays a vital role in determining the quality of city life." [3]

To fulfil this ambitious political aim the rail development strategy has been adopted as outlined in Figure 2.

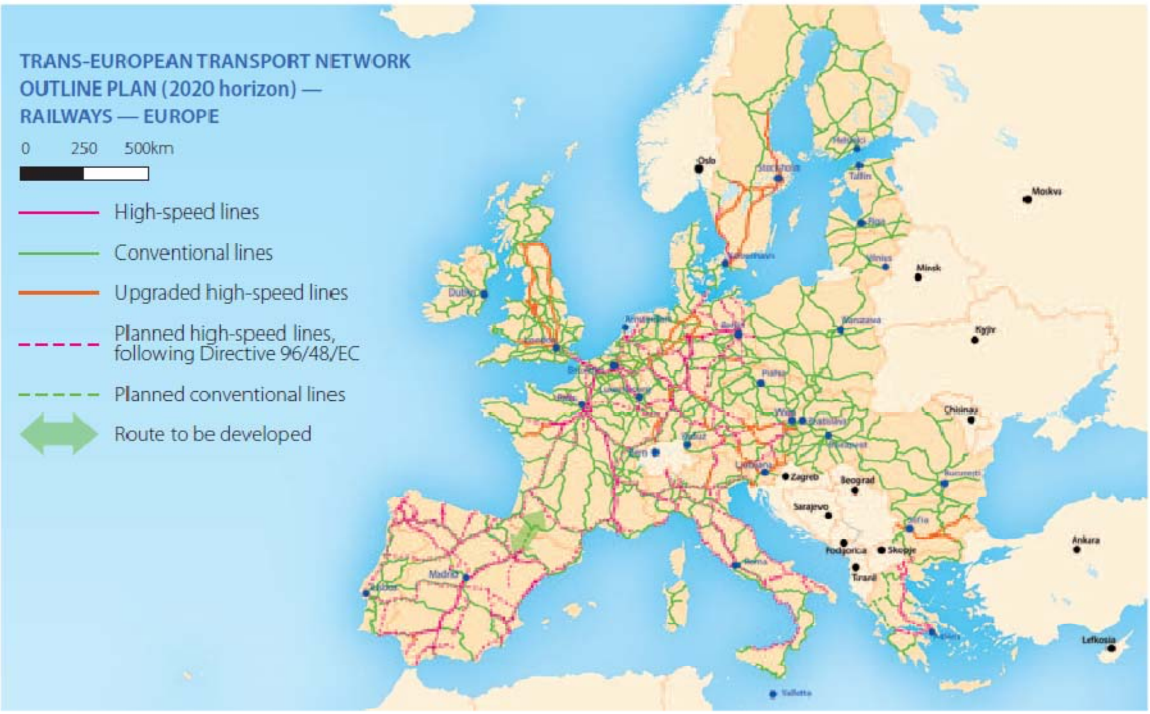

Figure 2: TENT- Railways outline plan till 2020 [4]

Europe needs to achieve this vision in order to reduce ecological and other threats of transport systems. They can be listed as:

- Rapid climate changes;
- Emissions in atmosphere;
- Traffic congestions;
- Green house effects;
- Melting glaciers and polar cap;
- Safety and security hazards [5].

The European Community therefore needs to create a transport system concentrating on the development of "co-modality", which is the optimal use of all modes of transport. This development is based in particular on creating a true internal European transport market. Much progress in this direction has already been made in the aviation and road transport sectors. However, rail transport still has some way to go in this respect. To breach this gap a first-indication map of the possible EU corridors giving priority to freight was consequently adopted (see Figure 3).

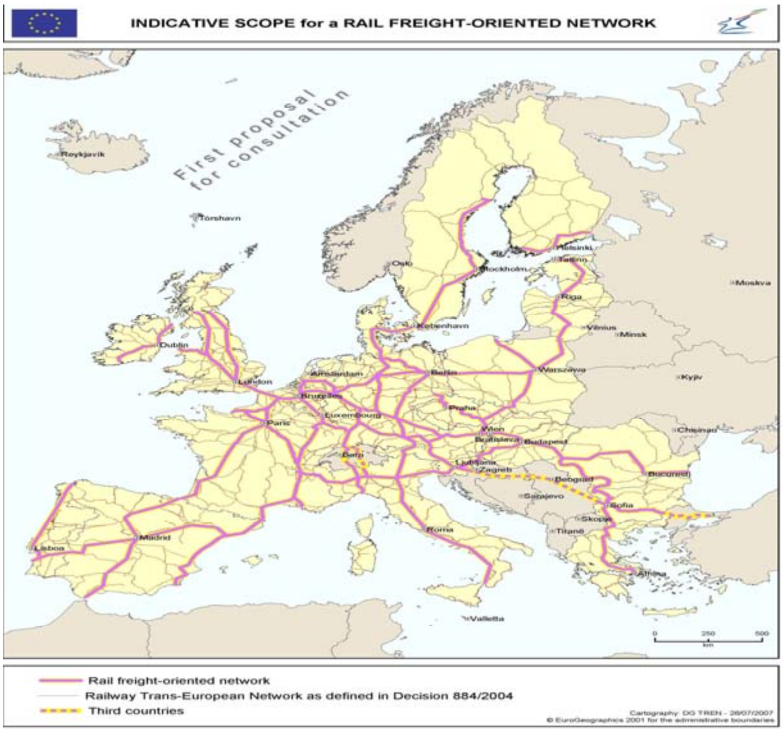

Figure 3: Indicative scope for a Rail Freight-oriented network [6]

The concept of “green transport corridors” including mainly railway links would be helpful to solve many of these above mentioned problems. In this context a very important barrier is that railway freight services were traditionally designed to serve domestic markets. That’s why crossing borders are sources of delays resulting from different track gauge, voltage systems, signalling systems or different rules on permissible loads, different safety and working practices. EU authorities say: “The European dimension is missing" [7]. It can be already said that today, the concept of green railway network giving priority to freight in Europe is being introduced. The implementation of such a network is by all means expected to improve and facilitate the movement of European freight trains having also positive environmental impacts at all. However, such an initiative (from design, organization and management perspectives) requires:

- Establishment of a number of corridors that will form this green freight network followed by precise identification and analysis of the specific locations (i.e. HUBs) in which reassembling the freight flows over this European rail network will be fulfilled;
- Railway infrastructure development for transportation services with freight trains and change from conventional to high-speed freight train services, identification of the critical points and analysis of the operating process (also involving resources and technology) with freight trains at the stations where the shift from conventional to high-speed services will be fulfilled;
- Infrastructure projects, investment plans and investment schemes, risk assessment of projects implementations, portfolio of projects involving international freight corridors in terms of a green network in Europe.

4 EU POLICY TOWARDS FREIGHT RAILWAY CORRIDORS DEVELOPMENT

Firstly, the beginning of 90s of XX c. should be mentioned. When issuing Directive 91/440, the European Commission had intended to reform the state-owned railway companies to become active actors in open and competitive markets. It demanded the economic independence of railway companies, the separation of infrastructure and operations, third party access to railway networks and solution of the debt problem of the railways. After six years, it has become clear that most EU member countries have been hesitating to implement the directive in its full scope and have opted for minimal solutions, often only fulfilling the formal requirements. As a result, the railways continue to lose market shares, while innovative logistics concepts rely on the flexibility of the road haulage industry [9].

The White Paper of July 1996, "A Strategy for Revitalising the Community's Railways" [10], promotes faster international railway operations and a strengthening of intermodal transport systems. As a first step, the paper proposes a network of so-called Trans-European Rail Freight Freeways (TERFF). After a lengthy consultation process, the first "prototype freeways", linking North Sea ports and Italy, were defined and presented to the public.

The main policy documents to be considered when dealing with the EU strategy for revitalising railways is the White Paper “European Policy for 2010: Time to decide” and its mid-term review. In the 2001 White Paper the Commission stated the key role of the rail transport in the European transport framework, accordingly to what had already been stated in the Communication in which the Commission had identified the need to establish a “strategic framework for Community action to revitalise rail transport”. In the framework of the strategy for revitalising rail transport provided by the 2001 White Paper, the Commission has identified the following points to be analysed:

- set up of rail transport finances and State aids rules to relieve the railways of debt and improve their finances,
- extension of access rights to infrastructure in order to promote the establishment of trans-European rail freeways with open access and simplified arrangements,
- higher quality and lower costs for users,
- integration of national systems through the promotion of interoperability for conventional rail,
- social aspects connected with possible loss of jobs due to rail sector restructuring within Member States [1].

As clearly stated in the White Paper “European Policy for 2010: Time to decide” and in its mid-term review, the Commission has pointed at three key actions to revitalise rail transport in Europe:

- integrating rail transport into internal markets,
- making optimum use of infrastructures by opening-up the market,
- building a dedicated European rail freight network, and promoting the modernisation of rail transport services.

A specific Communication issued in 2007 [11] deals with the objective of identifying a European rail network – consisting of corridors – over which freight should be given priority.

This would enable more coordination between member states and infrastructure managers and thus improving the quality of the service.

The promotion of freight rail transport is a priority in the European Union's policies and legislation. That's why three subsequent Railway Packages, each consisting of several Directives, have been introduced in the past 15 years, with the aim of promoting rail transport by opening up national markets and thus fostering competition and quality of transport. More specifically, the first and second packages aimed at gradually opening up the freight rail market (completed by January 2007) and restructuring the incumbent undertakings. They have produced the beneficial effect of decreasing rail freight costs by 2% per year between 2001 and 2004 and of decreasing rail transport tariffs by 3% per year. The Third Railway Package contains provisions about market opening for international rail passenger services, rail passenger rights and obligations as well as the certification of train drivers.

With regard to competition, many initiatives and actions have been taken and some others are under preparation. With regard to the quality of paths used by freight trains, the Commission considers it necessary to improve the existing situation/practices. It plans to do so by providing for better coordination between infrastructure managers and Member States on investments, management of infrastructure and ancillary services, and by ensuring that freight traffic is given an appropriate level of priority. The intentions of the Commission regarding these challenges were presented in its Communication of 18 October 2007 [12]. In this Communication, the European Commission explained the rationale for developing a rail network giving priority to freight. Given that the development of such a rail network should be gradual, measures should first target several strategic international corridors. These should function in an exemplary way providing, in particular, transparent information and non discriminatory access to the users of their infrastructure.

Another aspect addressed by the European Commission relates to technical interoperability and common safety rules. A key element in the development of interoperability is represented by the implementation of ERTMS (European Rail Traffic Management System), a common control, command and signalling system designed to replace the existing national systems.

In addition to this, the European Commission, in its policy of promotion of rail transport, has adopted a corridor-based approach in the context of the Trans-European transport Network (TEN-T). This has allowed the allocation of financial subsidies to rail development projects by means of the TEN-T funds. In fact, it is in this framework that ERTMS is being developed. With the objective of setting up a European rail network giving priority to freight, several technical and operational initiatives have been launched, especially the European Commission set up a strategic group of experts composed of representatives from Member States, infrastructure managers, railway undertakings, forwarders, ports and regulatory bodies to carry out an in-depth analysis of the rail infrastructure problems that faces freight transport (especially international traffic) [13].

The strategic group of experts also had the task of assessing Commission proposals regarding the creation of a European Rail Freight Oriented Network based on freight corridors (hereinafter corridors). The corridor approach was recognised by experience (ERTMS corridors) and expert judgement as the suitable foundation for a Rail Freight Oriented Network. The group took into consideration following studies/schemes/networks:

- ERTMS Corridors,
- ERIM (European Rail Infrastructure Masterplan),
- TEN-T (Van Miert Priority Projects),
- CER Report: Business Cases for a Primary European Rail Freight Network (2007),

- TREND Study,
- NEW OPERA's Network Perspective Report,
- RNE Corridors,
- EUFRANET (Improving Competitiveness of Rail Freight Services).

It should be added that the pattern of rail traffic flows on major corridors has not really changed in the last 10 to 20 years and existing forecasts indicate that in the coming years the pattern of traffic will not change, but that traffic volume will significantly increase. We could therefore expect that today's main routes will become even more important until at least 2020. On the other hand, the identification of corridors should not be fixed and should be capable of reacting to changes in markets. The reality of traffic flows can indeed change over the years. There is therefore a need for flexibility and sufficient capacity for adaptation to changes.

5 BARRIERS TO DEVELOPMENT OF RAIL CORRIDORS – EXAMPLE OF WEST-EAST ROUTES

The examples of practical adaptation of dedicated rail corridors are recent studies on viability of such corridors between East European countries (Czech Republic and Poland) and Netherlands [14]. Currently freight corridors in West-East relation are dominated by road transport with all its negative environmental consequences. This is mainly due to road transport tariffs being very competitive compared to tariffs of other transport modalities and because of greater elasticity of road mode. However, this may be changed if certain conditions facilitating rail transport are met.

In general - the concept of dedicated rail freight corridors could be useful for facilitating East-West trade flows only if certain operational conditions are met. Various barriers that exist in application of rail corridors concept are listed in Table 1.

Barrier	**Constraints**
Technical	Poor track condition
	Terminal inadequacy
	Terminal location
	Insufficient logistics
	Different technical standards adapted
Institutional	Access fees
	Lack of policy and operation coordination
	Different regulations across countries
Economic	Insufficient demand
	Competition from other modes
	Insufficient marketing policy
Operational	Lack of schedule harmonisation
	Skills of train drivers
	Lack of common procedures

Table 1: Mix of barriers in development of dedicated rail corridors (Own elaboration based on [17])

The above barriers are often mixed and reinforce themselves. For instance the lack of infrastructure prevents creation of logistic centres and increases price per unit. The most significant obstacles are those of technical and market types. Firstly there are infrastructure restraints. The state of infrastructure, lack of sufficient rail links from the interior to the main West-East line (on the part of CEE countries) could reduce cargo flows significantly. This could be remedied by creation of logistic centres – a platform allowing for moving cargo from road oriented transport into rail. Road transport could serve as a collecting unit from various modes in area around designations or origin points with cargo being consolidated at logistic centres and send via rail over long distance.

Another barrier constitutes lack of adequate rolling stock and sufficient carrying capacity for freight traffic. This problem is intermingled with operational barrier of lack of cross-acceptance of locomotives between different rail operators across border. The other problem is unification of traction, communication and interlocking equipment between participating bodies. Currently in Europe we have 4 traction systems and even more signalling systems. Between participating countries of analyzed rail corridors (Poland, Czech Republic and Germany/Netherlands) this is mostly limited to incompatibility of ERTMS equipped locomotives which cannot enter participating countries because the systems within the Netherlands, Germany, Czech Republic and Poland are not synchronized.

The problem of terminal location and its inadequacy could also handicap this type of projects. In general there is a problem with location of logistic terminals with throughput capacity sufficient to quickly ensure intermodal shift from road to rail mode. The more serious problem is geographical dispersion of potential cargo sources. In case of Czech Republic, the problem is alleviated due to the fact that major transport links are all concentrated in Prague, thus Prague terminal could serve as end/start point. But it is not a case of Poland where at least two routes should be planned: one central/northern to cover Poznan/Szczecin area with further link in the interior to Warsaw, Lodz and with possibility of northern extension to Gdansk. Second route should be through southern regions, through Wroclaw/Katowice and Krakow area. On those two routes only Poznan and Wroclaw/Katowice areas have some form of cargo hub/processing centres capacity. Moreover to make the corridor profitable probably further extension into Belorussia and Ukraine should be considered from eastern side and possibly extension to France from western. However, apart from obvious infrastructure problem there is a question of sufficient demand. The major cargo types in Belorussia/Ukraine transports to the West are not too highly processed raw materials or agriculture products. This is hardly a cargo which may achieve preferable transport cost/value ratio.

For institutional problems we still face a problem of different systems of accounting infrastructure access fees. It could be argued that for the rail corridors to be competitive charges for using electricity or other facilities should be calculated based on consumption instead of flat rate. The recent Polish – Dutch study calls also for introduction of the EICIS (European Infrastructure Charging Information System) on corridor to calculate path charges, station and shunting fees during path request process.

Significant legal barriers do exist. To overcome them a similar legal environment like in the Rotterdam-Genoa corridor case should be made. To enumerate just the most significant agreements that have to be put into effect: the agreement on the implementation of cross acceptance of approval procedures for rolling stocks and agreement on cross-acceptance of approval procedures of the competent supervisory authorities between the rail safety authorities on the model for cross acceptance of engine drivers (modelled after the agreement signed by Germany and Netherlands in 2005). Further cooperation between rail authorities of participants is important - cooperation of the national rail regulator on the monitoring of international path allocation process and cooperation on European rail traffic management system (ERTMS/ETCS).

The most significant precondition for development of any rail corridor is sufficient market demand. It could be argued that demand is insufficient due to poor conditions (operational/technical) of current multimodal offer. Reduction of number of multimodal trains witnessed on some routes could also be attributed to general economic conditions. For example during recent economic crisis (2009) number of intermodal trains between Poland and Netherlands through Germany has been reduced from 8 to 6 per week [15]. Proponents of corridor concept put forward an argument that if adequate technical platform is offered in terms of easy procedure, short loading/unloading, as well as transfer times the demand will increase. They point out that current state of logistic centres in rail mode in Eastern Europe prevents wider acceptance of this mode of transport. Certainly logistical centres are necessary in order to collect enough dispersed cargo transports to form a train. In spite of the existence of several intermodal terminals in Poland or Czech Republic, the need for upgrading and expanding the existing terminals and also the creation of intermodal terminals has been clearly noticed among the railway market participants. Without them the delay in waiting for train formation is simply too long to be accepted by exporters/importers on both sides of the corridor.

But there is also a question about competition. In case of Czech Republic it is only road transport but in the case of Poland it could also be competition from seaports. After being loaded off at Rotterdam, most maritime containers are transported further to Poland by feeder vessels. Those feeder connections are generally significantly cheaper than container transport by rail. Rail connections compete in that they are faster and can reach inland locations directly. Therefore, when setting up a rail service between Rotterdam and Poland, it is suggested to consider acquiring also continental containers in the hinterland at rail-hubs. What is interesting for import/export companies flexibility, time savings and ease of use are often more important than direct costs [16].

Another barrier presents human factor. Railway personnel is not always capable to speak foreign languages. If German or English are selected as operating languages it may become a preventive barrier since East European locomotive drivers often cannot speak other than native tongue. Other operational difficulties that might arise have to be considered. For example examination of the possibility of early informing, or possibly suitable re-routing of consignments in a case of extraordinary limitations on the route, on-line monitoring of consignments (trains) on the territory of the individual states.

Apart from general problems the specific problems of East European dedicated rail corridor could be identified like external accessibility of rail hubs (which is poor in both Czech Republic and Poland), accessibility of other transport modes infrastructure (e.g. ports or river ports – which may prevent cargo collection from gravity areas at end points of the corridor), old rail infrastructure reducing speed and causing technical failures. There are also possibilities for delays on border crossings and time loss due congestion (especially during transfer on highly used German network). Congestion on tracks limits possibility for seamless operation of dedicated freight corridors. For example in Germany there were 3000 minor and mayor maintenance projects in 2007. Moreover, the rolling stock, drivers and train paths are close to optimally used which means that all flexibility and reserve capacity is used. Small disturbances lead directly to lost train paths and delays in the whole corridor.

6 CONCLUSIONS

The general need to facilitate rail transport within Europe is widely recognized and accepted. However, there are many problems with introduction of the concept to real transport sector. In freight transport one of the answers to the question *"what next and what is the future of the European Rail Freight Operators?"* could be development of dedicated rail corridors. This concept has been tested in practice on Rotterdam – Genoa path and currently the idea is being studied in West-East relations. The obstacles here are bigger and possible failure more likely due to higher degree of technical, operational, legal incompatibility between EU-15 and EEC countries.

On the European level increasing share of rail transport in overall cargo transports might be achieved by actions like:

1. Imposing real pressure on the European rail freight operators (in the public sector) by solid and rigid political measures in order to increase their operational efficiency; to deliver values for money to their customers and hence reduce long run deficits;
2. Encouraging intermodal, multimodal, and co-modal freight transportation services at international, national and even urban levels in which rail would play a significant role;
3. Concentrating the freight flows in a number of freight transportation corridors (Green Transport corridors for freight).

In specific situation of EEC countries additional conditions have to be fulfilled:

1. Improving technical infrastructure of railway;
2. Creation of logistic centres capable of processing of high volumes of cargo;
3. Improving interoperability with EU-15 rail network.

Given sufficient political will most of the above requirements could be achieved till 2020 fulfilling general aim of better more user and environment friendly transport.

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ABOUT THE FUTURE PERSPECTIVES OF INLAND WATERWAY FREIGHT IN CENTRAL EUROPE

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ABSTRACT

The paper collects arguments to present that the consumption- and emission characteristics of the rail and inland navigation modes are very close to each other. Considering that these modes are able to transport more or less the same groups of goods, it is a much better way to develop them within an integrated transport policy than trying to bring arguments for one of them against the other.

1 INTRODUCTION

It is a good choice, that the 6th SoNorA Think Tank meeting deals with the rail freight and the inland waterway freight issues together, giving a chance to avoid supporting one of those transport modes against the other. This paper presents historical, geographical, consumption and emission characteristics of the two modes for promoting arguments along an integrated transport policy and against a frequent one sided presentation of waterway advantages.

The paper presents the appearance of the different dominant transport modes in a historical background and introduces a hypothesis that these tendencies are to be changing in the future. The next part underlines that statistical data do not prove the expectations about the unexampled low inland waterways emissions and consumptions. The last block compares the possibilities and practical circumstances of the Western, Eastern and Central European (landlocked) inland navigation, to show the differences between countries of different endowments, and to avoid an expectation to consider those countries with higher share of inland water freight as a target to achieve.

2 INLAND WATERWAYS WITHIN THE TRANSPORT SYSTEMS

Until the middle of the 19th century waterways were the main carriers of long-distance terrestrial(!) goods transport – the alternative was the animal-driven cart. Even on the rivers in the case of the upstream transport the human or animal haulage was prevalent.

The rail, the paved road, the automobile and the airplane all appeared as *new technical inventions*, and possibilities to take over the load from the previous actor. In the history of the past two centuries of the transport there was always a (time-to-time changing) *dominant transport mode*, and accordingly a dominant infrastructure that determined the possibilities of the transport ([1]; Figure 1).

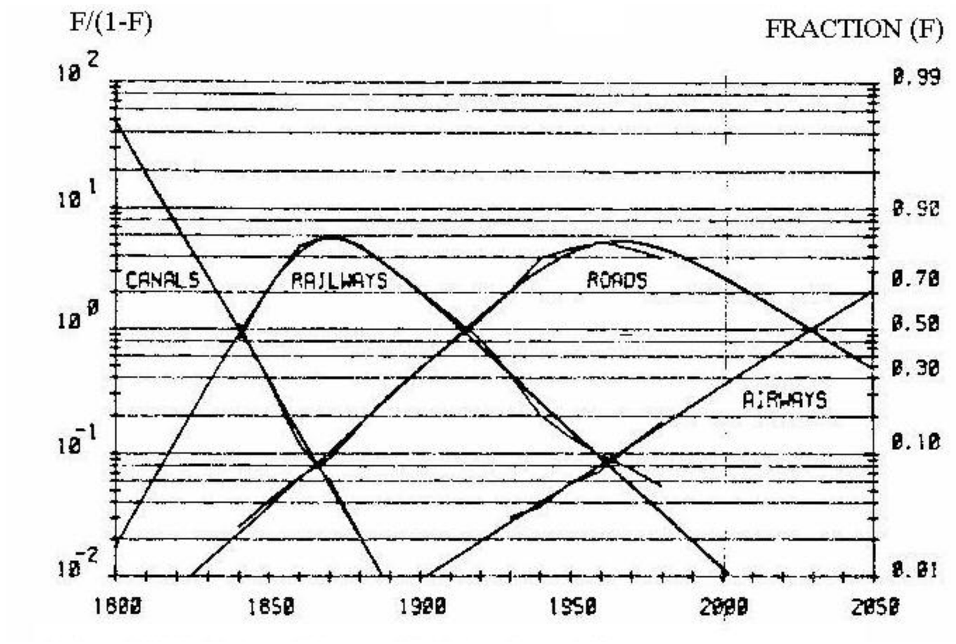

Figure 1: Substitution of transport infrastructures in the USA 1800-2050
(Fraction of the given mode in length of the network relative to the others) [1]

Not regarding the proportion of modes relative to each other, but the process of the growth of the infrastructure network of different transport modes, *Ausubel et al* [2] manifested that those modes coming later dispose with longer development period and more and more moderated dominance relative to the other modes (see Figure 2) Based on those results, we added a hypothesis, that the earlier ("outmoded") transport modes do not necessarily have to totally finish their cycle of development, rather stabilising it at a lower level. From such a hypothesis by the 21st century a mixture of modes has evolved, where each transport mode may have a given share from the total transport, without the sharp domination of a specific one competing with the others. We see that such an approach also suits to a post-modern paradigm, where a mixture of the existing heritage can be well coupled with new innovations, and the technology is used also to achieve the good amalgamation of the different segments. The task of the transport policy here is to promote the cooperation of the different modes in an integrated, co-modal transport system.

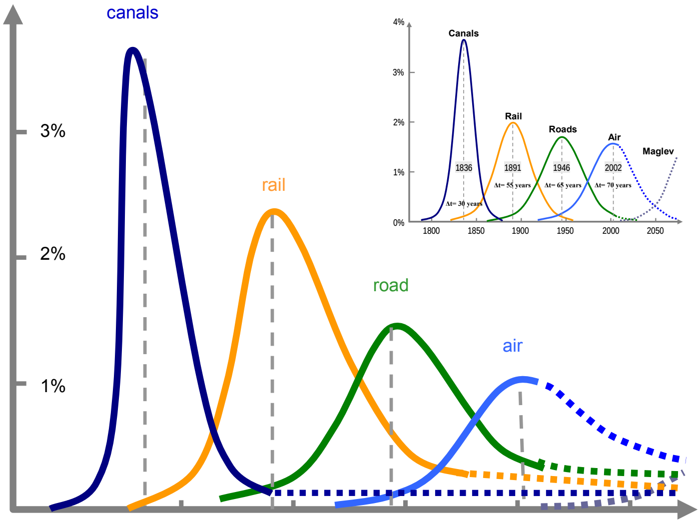

Figure 2: Mixture of modes in the 21st century. Based on the growth of the US transport system, 19th - 21st century (right upper corner) [3] who reproduced [2]

3 INLAND WATERWAYS: FIGHT FOR A BIGGER SHARE BASED ON UNCERTAIN STATISTICS

The present-day situation is totally different from those described above. Even the modes in a weaker position try fighting against the other modes, and achieving a traffic gain at the expense of those other modes, supposing a 0-sum game in the transport market, where the modal growth is an accepted target.

That is why a great portion of the existing background papers dealing with the inland waterways offer unbalanced argumentations for catching a bigger share in the transport market, without an extended analysis of either the integrated transport situation or the sustainability targets.

There are sustainability boundaries (pressure for less energy use, need of less emission output) that are really favourable for the rail and the navigation, and unfavourable for the air and road transport. Railways and waterways together should form those integrated transport segments that could offer transport policy level solutions for sustainability problems. If rail and water tries to rival for the goods instead, they both may miss those potential advantages coming from the integration, and also the whole economy is a loser in the game which is obliged to construct parallel capacities instead of integrated solutions.

The non-confirmed arguments that try to improve the positions of the inland waterways against the rail can even appear in official DG-TREN positions, using uncontrolled numbers. The main page of the inland waterways writes: “Its energy consumption per km/ton of transported goods is approximately 17% of that of road transport and 50% of rail transport” [4]. *Piekarski* [5] also refers to EC documents [6] writing: “European Commission studies indicate that with only one litre of fuel most vessels can transport one tonne of cargo over 127 km, in comparison to 97 for rail and 50 for road.”. The same numbers are presented on the figure, too ([5] Annex D, p. 118), referring to www.inlandnavigation.org; while now looking at that site we can already see another figure with slightly different proportions and with very different values relating to five litre of fuel use instead of one (Figure 3).

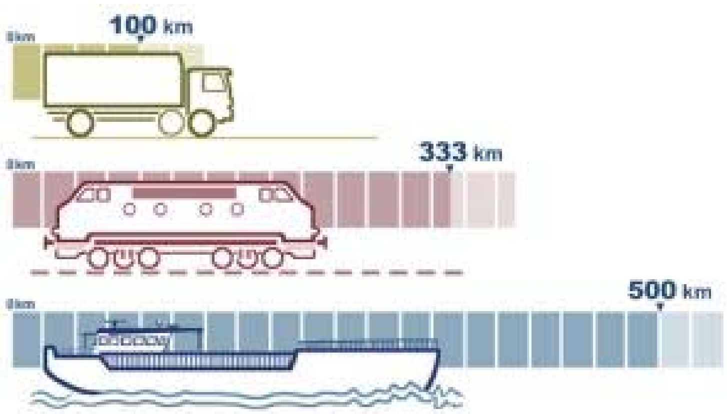

Figure 3: Five litre of fuel equivalent enables the transport of one tonne of goods over the above distances [7]. By those numbers 100 km transport needs 5 l, 1.5 l and 1 litre of fuel respectively

It is not easy to find those sources that can support any of these proportions with real numbers. Those international statistics publishing county level final energy consumption data by transport mode (Eurostat, UNECE etc.), can't distinguish the energy used for freight, so, first of all rail and road statistics say nothing on energy consumption per km/ton. To find data it is necessary to see single researches.

In Hungary the specific energy consumption of the water freight was really half of the rail until 1990 (ca 150 KJ per ton/km versus 300 KJ per ton/km; [8]). In that period the official statistics contained five times more ton/km marine transport performance than inland navigation. During the next five years the Hungarian state got rid of the Hungarian flag marine fleet, and by 1994 when the statistics covered necessarily the remained inland navigation, the energy consumption of the water freight changed to 600 KJ per ton/km – much worse than the rail that held the 300 KJ per ton/km value.

More extended and more recent comparison was made by *McKinnon* in the UK [9]. He measured CO_2 emission rather than fuel consumption, and found the average CO_2-intensity for rail freight operations in the UK was 14.5 g CO_2 per ton/km. This result was lower than other results he also surveyed and compared[1]. The emission depends to a great extent on the haulage and could be summarised as 15-20 g CO_2 per ton/km in the case of electric haulage and 35-40 g CO_2 per ton/km at diesel haulage. In the same time the freight on inland waterways emits 30-40 g of CO_2 per ton/km [14], [16]. As an average there is no difference between the specific emission of the rail diesel and the inland navigation, while the rail is better if using electric haulage. McKinnon summarised the average emission intensity for different modes as follows: air freight 1600 g of CO_2 per ton/km, vans 220, heavy trucks (>38 tons) 160, inland waterways 35, coastal shipping 25-30, rail 20 g of CO_2 per ton/km.

We don't have to accept the above results as something that can be generalised for the rest of Europe, but we can confirm the hypothesis that *practically there is no considerable difference in fuel intensity and in CO_2 emission intensity between the rail and the inland navigation, while they both represent a relative good performance within the transportation*.

1 „For example, the Rail Emissions Model constructed by AEA Technology [10] for the SRA used a ratio of 20 gm of CO_2 per tonne-km for rail freight. The TREMOVE study, undertaken by the University of Leuven, [11] assigns a value of 33 gm of CO_2 per tonne-km for UK rail freight operations. Four other recent studies by NTM [12], WRI-WBCSD [13], INFRAS [14] and IFEU [15] suggest average ratios for European rail freight operations of, respectively, 17, 30, 38 and 18 (electric) / 35 (diesel) gms / tonne-km." [9]

4 INLAND WATERWAYS: ARE THERE WESTERN PATTERNS TO FOLLOW?

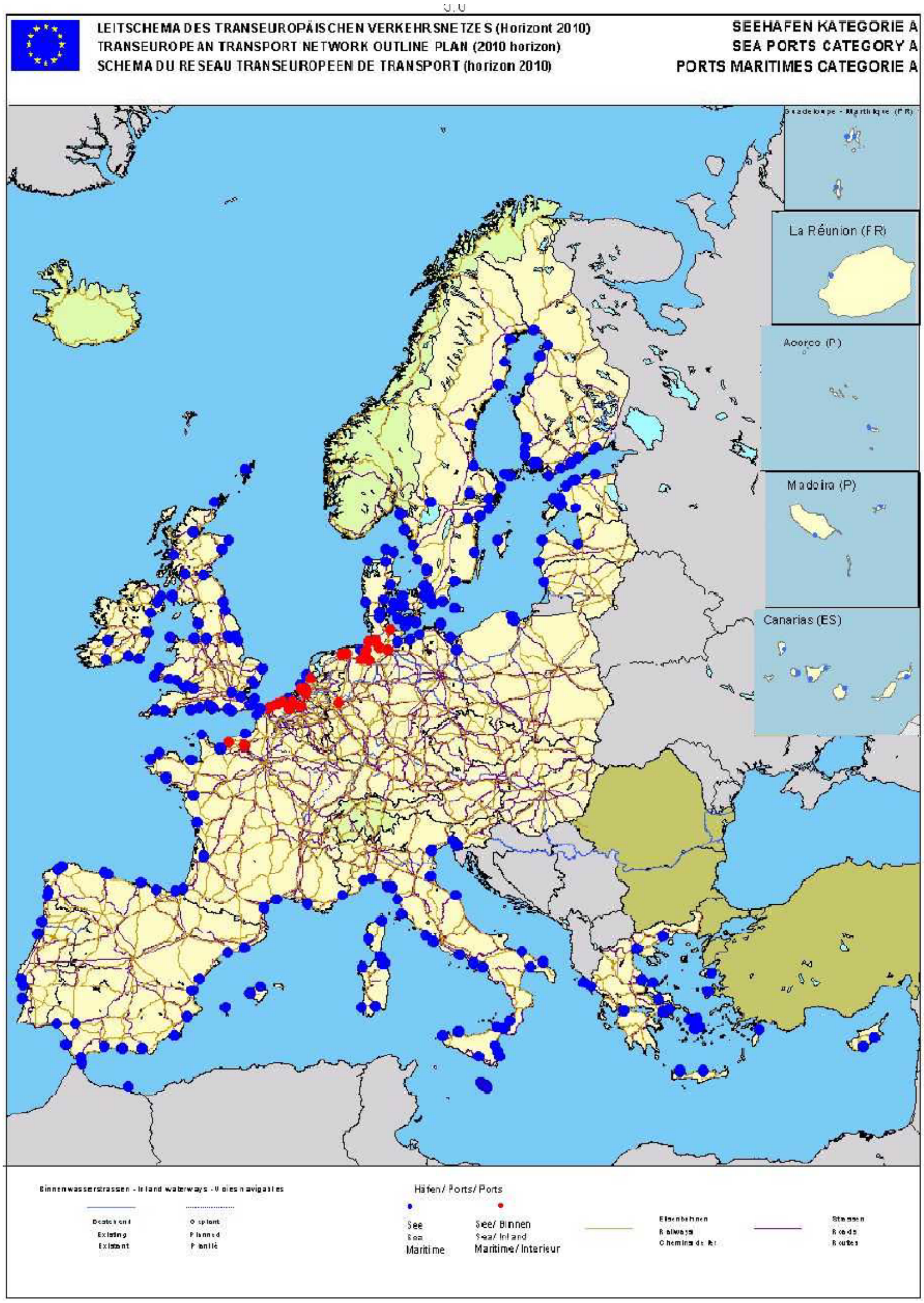

Figure 4: First category sea ports and sea/inland ports in Europe [17]

Besides the fuel-consumption and emission arguments, there is another frequent argument for the development of the share of the inland navigation in freight transportation, namely the example of countries, where this proportion is much bigger. There are different statistics, (pipelines included or not, tonnes or ton/kms etc.) here we use the Eurostat 2009 statistics for the year 2006. By that basis the share of the inland waterways freight transport performance (ton/km) within the total freight performance was 5.6 % for the EU-27s; while the same share for the EU-15s was 6.5 %.[18] In Hungary the same number was 4,5 % in that year.

Does this mean that Hungary is lagging behind Europe, or that the new members have to catch up with the EU-15s in inland navigation? If we study how that 6.5 % was split between the countries of the EU-15, we can find that there are three leader countries of the EU-15 (Netherlands 32.3 %, Belgium 14.7 % and Germany 12.8 %) – while the other EU-15 countries have smaller inland water freight proportion than the EU-27 average or even than that of the Hungarian share. In the eastern side there is also one country, Romania with 10 % as leader in navigation.

What are the common characters of those leaders? All of them are maritime countries, also with important river mouths. As for the western three, they also dispose of old canal systems parallel to the sea-shore between the rivers, forming a network of waterways (generally from the early 19th century on). Looking at the ports (see Figure 4) there is also a distinction between sea-ports and sea/inland ports, as especially in the case of the three above countries the big ports are far into the continent, in the horn-mouths of the rivers [18]. In the case of Romania the situation is different, the Danube has a delta mouth, not offering a good sea port, instead Constanta grew to a big Black Sea port, and it was recently linked to the Danube with a canal.

Even on the Rhine, there is a ten times difference between the navigation performance of the river-mouth and a cross-section 700 km upstream. There is also a difference what economic navigation means depending on different shapes of river cross-sections. On narrow and deep rivers a different fleet evolved, than on the wide and shallow eastern European rivers.

Cheap water freight means, that if the goods are in the well loaded barge, the movement of the goods is cheap. If the fleet and the river-bed is different, or the fleet and the ports are missing, or if there is no market for those goods – the cheap transport has no meaning any more, until all those conditions are created.

*

Here we can stop with comparative arguments and turning rather to a sustainability background. On the one side sustainability means that we have to be able to accept that we need to adapt our activity to the endowments, and we can't keep our previous plans at any price. On the other side sustainability really offers a good opportunity to the low-emission transport modes as rail and waterborne transport, but it needs an integrated policy approach to implement new measurements for promoting both those modes. It is not enough to refer to sustainability argument, and behind that trying to pass old, outmoded plans in favour of an old and outmoded transport model.

There exist already good surveys to support a more detailed analysis. We can learn, it is not enough to sell wishful thinking as traffic forecasts [19]; it is not enough to deny emissions coming from waterborne transport for showing a better comparison [20]. It is also necessary to study not only the advantages, but the weaknesses of inland waterways, too, (good example is [5]) because it is not against the other modes, but along the common possibilities of the rail- and waterways that a positive scenario can be constructed for the future transport policies.

5 CONCLUSIONS

The different documents promoting the development of the inland navigation are all count on the limitation of the future resource use and emission, but rarely draw more conclusion, than that it is favourable for the inland navigation. This paper attracts attention to the fact that the myths of the unexampled low energy use and low emission of inland waterways is not proven in the practices, and an integration rather than a competition with rail would promise more results for the future.

Proposals that try to show countries with high share of inland waterway fright as quantitative examples to follow to other countries are also false. Those countries all dispose with special endowments and old traditions of navigation that can't be copied by land-locked countries or countries with very different background. In that context the adaptation to the environmental endowment is again a good point of orientation.

The sustainability approach can really offer a good possibility for the development of the inland waterways, but this transport mode can gain from that only by conforming itself within an integrated transport policy frame, and in close cooperation with other modes instead of competing against them.

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RIVER TRANSPORT PLANNING IN SERVICE OF THE EFFICIENCY

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ABSTRACT

In Middle-Europe the traffic outputs don't reflect the theories of conception on sustainable transport. The dividend of inland navigation from total modal split is insufficient. What are the reasons of the state of being slighted? How can the well-known ecological and economical advantages of shipping be enforced? It is important to gauge the specialities of river transport planning.

Beside network development, infrastructural modernising and a suitable charging policy it is important to improve reliability if you wish to take the advantages of waterway transportation. As a basis for this an appropriate transportation planning system is needed. The study defines the systematic elements of transportation, and also reveals the influential nautical and operation factors. Furthermore, the study gives details on principles and obstacles of creating ship formations. Finally, the study will give hints on different methods of improving transportation efficiency.

1 A 'STEPCHILD' OR A PHANTOM? / NEGLECTED OR UNKNOWN?

In spite of the well known fact that shipping has many advantages as it is economical, environmental friendly and safe, its modal split rate is quite low. The Netherlands are kind of exception with their 40%. Even on the waterway system of the river Rhine a rate of 20% is achieved only in few countries [1]. To reach this rate on the Danube seems an utopist idea. This may be an astonishing fact knowing that shipping is a proper way of transporting big masses to far distances. When defining transportation performance you need to form a product of much bigger elements. The basic formula [2] for a vehicle fleet in a selected period of time is the following:

$$P = \sum_{i=1}^{x} \sum_{k=1}^{z} M_{i,k} \times D_{i,k} \qquad (1)$$

where: P: total transportation performance

$M_{i,k}$: mass transported by vehicle number i on its transportation route number k

$D_{i,k}$: the distance covered by vehicle i on the transportation route number k

x: number of transportation vehicles used

z: number of routes in a selected period of time

As M and D are high numbers, a low level of total P, compared to other fields, is caused by the low level of x and even more that of z. Consequently, there are few ships and they have hardly any transport which results in a very low transportation frequency. As a result, P is low, too.

Shipping is claimed to be slow, so it is often ignored. Insufficient technical speed is a solid feature that cannot be improved. However, due to its trading (forwarding) speed shipping is competitive when it comes to transporting big masses to far distances. For example, 10,000 tons of load is transported from Austria to the Black Sea within shorter period of time on a pushed ship of craft than doing so by using the vehicle fleet of a road transportation company.

The other major problems are spatial availability, the limited network system and the really low number of proper ports. As a result, shipping is involved in combined transportation chains. With combined technology on- and off-transportation are easy to plan and organise. Nevertheless, it is still shipping that takes the most time and distance in the transportation process. Due to external natural effects shipping is the least reliable way of transportation considering punctuality. That is why the shipping route section requires the most appropriate calculation, timing, planning and organizing to carry out bimodal transportation tasks properly. You can improve reliability by competent planning which may result in a more widespread use of waterway transportation.

A further problem that you must not neglect is the lack of knowledge. According to various surveys, actors involved in transportation have insufficient knowledge of shipping, so they are often reluctant to take decisions of great responsibility. In education and training of shipping experts waterway technology is hardly or not at all covered in the curriculum. Consequently, for these people planning a shipping route within a combined transportation chain is a deterrent job, or task management is very superficial. To resolve the ‘mystery’ of shipping and create a unique basis, the European Union has launched the project NELI. The training in the project program involves the actors of logistics who can contribute to making plans [3].

The aim of the present study is also to contribute to improving waterway transportation by optimizing transportation task planning.

2 PLANNING TRANSPORTATION ON RIVERS

The planning process consists of structural and action phases. Concerning structure, we are in process of preparation-elaboration-completion. Action consists of the following steps:

- defining tasks
- defining system elements
- revealing influencing factors
- matching
- modifying
- developing versions
- checking
- completion

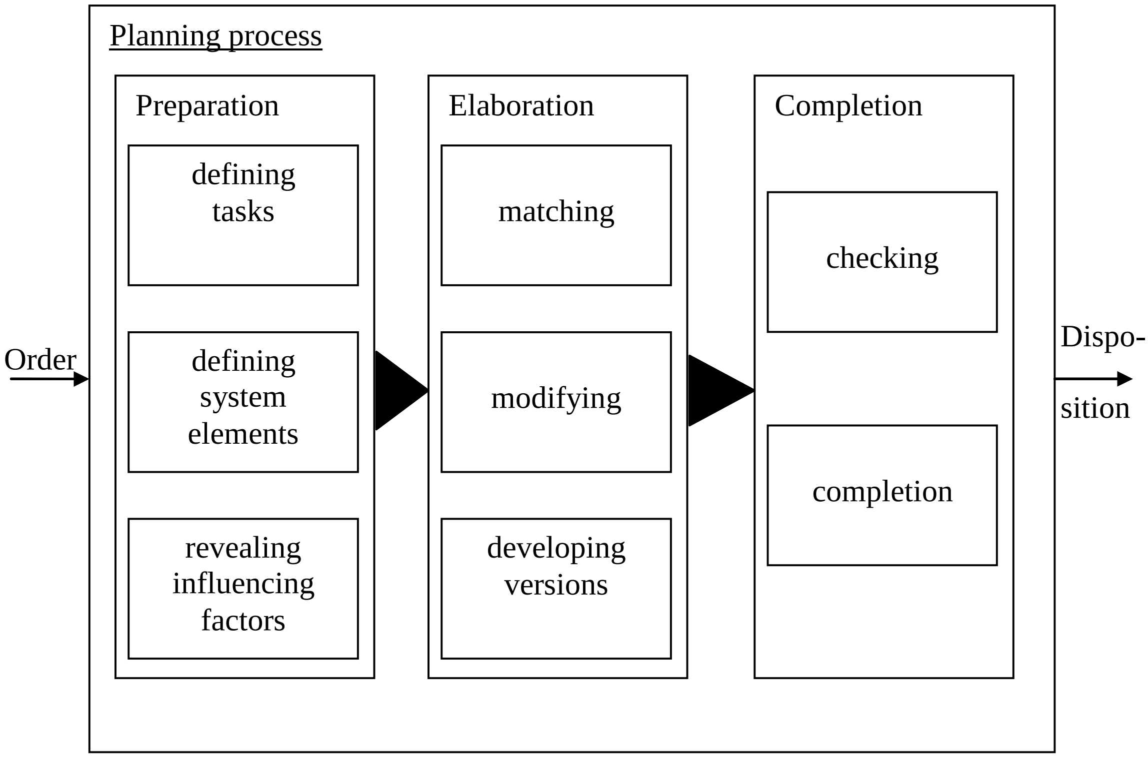

Figure 1: Phase model of transportation planning

2.1 Preparation of planning

The role of preparation of planning is to reveal the bases of a transportation task and detail basic data.

Based on orders the task can be defined. Firstly, you define the character of transportation (if you transport people or goods). If you transport goods you have to define the character of joining the transportation chain (if you transport only by ship or it is a combined bimodal or trimodal process). All these characters affect the application.

Elements of transportation task:

- goods
- vehicle
- relation
- period

The load, the on- and off-loading station and transportation deadline are set according to the needs of the contractor [4]. The transportation vehicle is usually provided from the ship fleet of the transporter. In case of leasing vehicles from an extern company the vehicle fleet is obviously extended. The transportation route on river waterways (from the starting point to the destination) is mostly given, there are alternative option routes only in the region of the river Rhine.

You can define the influencing factors of the single system elements. Influencing factors of transporting goods:

- type (piece or bulk goods)
- physical condition (liquid or dry goods)
- specific density and loading co-efficience
- size and geometry of a loading unit
- way of storing and packaging
- amount

Required features of ships:

- type (according to loading and shipping technology)
- capacity (data on volume and mass)
- data on extern size
- store geometry

Input data on relation:

- spatial features (ends, distance, inner section size)
- features of hydrology and
- hydraulics

The transportation period can change the meteorological and hydrological conditions on the route. The increasing transportation distance, the variable shipping route, the fluctuating streaming speed and the ever increasing number of various shipping actions have a degressive effect on the reliability of waterway transportation (see Figure 2).

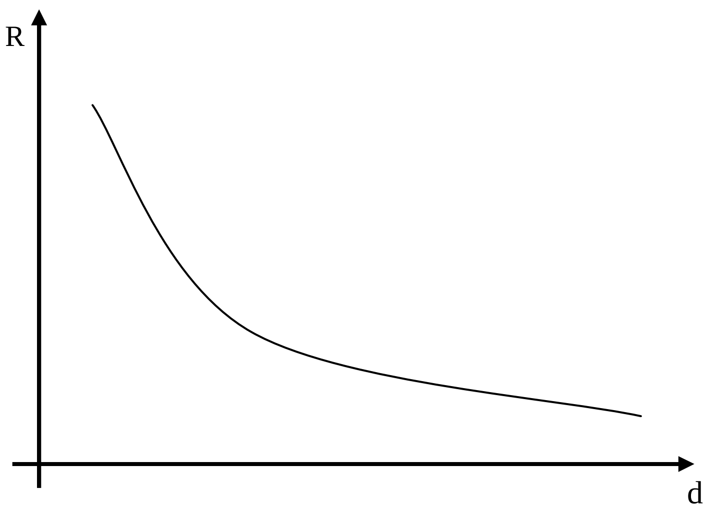

Figure 2: Reliability of waterway transportation against distance

Various spells and seasons may disturb planning and calculation (see Figure 3): spells with water level changes, ice and floods.

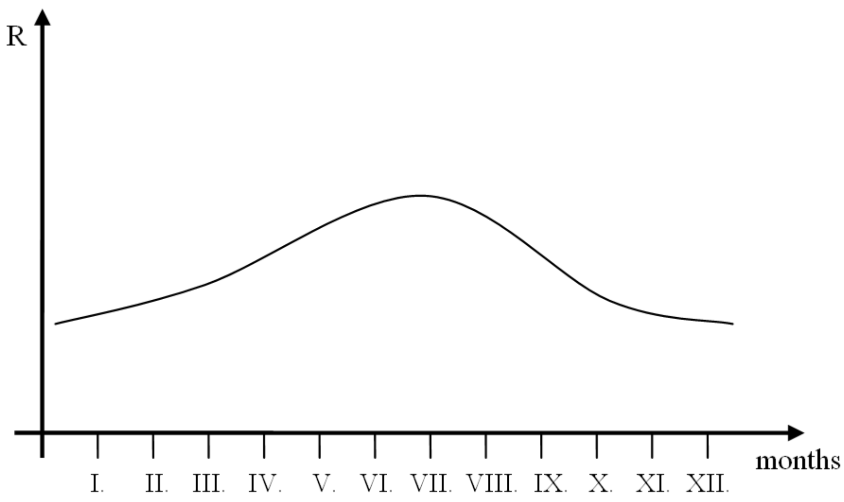

Figure 3: Reliability of river transport by seasons

2.2 Elaborating transportation task

During elaboration we follow some earlier defined aspects to fulfil the set aims. Planning has operational and nautical aspects.

Operational aspects:

- harmonizing load and vehicle (according to type, amount and other features)
- considering range of engine ship (fuel and food supply, technical service)
- adjustment to operating time of ports and sluices

Nautical aspects:

- calculating hydrological conditions
- application of vehicles adapted to shipping route features
- considering transport restrictions.

Major purposes of planning:

- best utilization of ships (concerning mass and/or volume)
- with the right trim position and
- suitable stability,
- keeping load safe (by proper loading and storing)
- minimizing transportation time [5]

The input elements are adjusted by matching the above listed aspects and purposes. Since both the elements and factors are complex, it is almost impossible to carry out a perfect adjustment. You can solve this problem by making a list of preferences with varied options.

The task is even more difficult if you have to plan and organise transportation with a formation of several ships. Beside criteria applying to single ships you have to take a set of criteria into consideration when forming ship caravans:

- an optimum size according to the waterway capacity
- sufficient engine ship performance to enable special movements, manoeuvres
- obeying official restrictions applying to any waterway section
- creating up- and downhill forms according to actual direction
- positioning in the caravan according to load line
- connecting ships considering destination port
- separation of dangerous goods.

It is not possible to meet each criterion at the same time, thus, it is advised to make a list of priorities. Although you usually have to meet only one or two of the criteria, planning still gets divergent [6].

2.3 Completion of transportation task

The single versions must be checked concerning all the transportation relation. In case of any differences new amendments actions and checks are necessary until differences disappear. It is especially difficult to forecast changes that occur during the transportation process. Being a major issue, the time factor needs high consideration. By doing so, and after a repeated check and realization of the required amendments, it is possible to make the final version of the plan, and also issue the executive order to start transportation.

3 AFFECTS OF TIME FACTOR IN PLANNING

Transportation on river waterways can be regarded as a reliable service if you are well prepared for occasional and unexpected conditions on the way. While planning the transportation process, you can select stable elements, like type of ship, loading machine. However, different positions of the transportation vehicles and various features of the waterway require considering time factor for the single phases. There may occur static and dynamic effects. You need to take the positioning list into consideration only to calculate starting time of the ship, though, the waterway features continuously fluctuate during a long transportation process. The time factor has direct and indirect effects on elaboration of the transportation process (see Figure 4).

Technological development allows more and more reliable solutions for calculating changing circumstances. Earlier you could base your calculation on own experience, then it was possible to get reports on daily water level and shipping positions. Today it is possible to be informed about any required data any time.

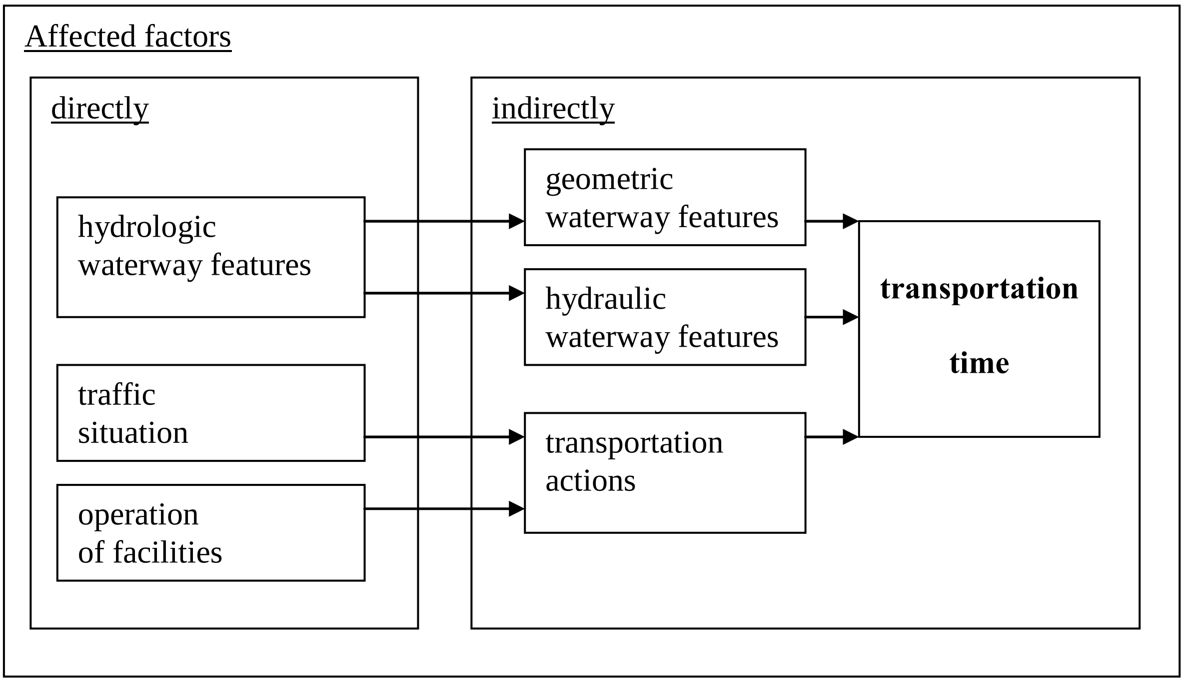

Figure 4: System of time affected factors

3.1 Classical calculation

With classical calculation you determine the inner section size and streaming characteristics based on available water level data. Loading, load level and height of ships is adjusted to the most crucial points of the whole transportation way. Starting parameters are usually calculated with statistical methods using water level measurement functions. It is not possible to establish any deterministic relation between the single way, and also, the available relations are only effective under stable hydrometeorological circumstances. In case of up-swollen waterway sections natural water stream relations are irrelevant. The waterway characteristics are determined by the operation schedule of power stations and flood prevention management. Classical calculation for these areas is only possible by approximation. As a result, ships are forced to stop and wait during transportation. Major reasons:

- one-way traffic in narrow waterways
- limited depth in swallows
- partial passing of big ship formations at locks
- compulsory use of a towboat at sections with heavy streams.

All these constraint actions and waiting time can even exceed expected transportation time by 20-70%. This time is extremely long due to miscalculated swallow depth values. In critical cases ships can travel on by reducing weight of load.

3.2 Dynamic planning – 4D-shipping

The most crucial points of planning transportation are the changing parameters concerning time and space. The most effective way the situation can be improved on frequently changing waterway sections (like that on the river Danube in Hungary) is waterway development and maintenance. Without these planning it needs bigger consideration.

You can solve the problem of time changes in several steps.

1. Firstly, you need to specify data on starting time. You have to switch from static to dynamic state evaluation. The expected waterway parameters can be adjusted according to the time the parameter is expected to be relevant. To do so, you need to calculate with transportation time and passing of water output.

The size of inner sections can be harmonized with load and size of the ship. Selecting the most appropriate ship is of great importance, as we cannot expect any changes of the size of the selected ship during the transportation process. Potential actions in case of negative forecast:

- change starting time (if transportation deadline allows it)
- use smaller vehicle units (if available)

2. Secondly, accurate timing requires considering time factor. 4 dimension shipping enables you to trace occasional changes of restrictive cross-sections during the whole transportation process. If changes are negative, the most evident solution is to postpone passing on. If you are aware of changes well in time, prevention is possible. Potential adaptation options for ships of given size on the waterway:

- timing of passing on at critical sections considering flexibility of travel speed (with a towboat if economical) (see Figure 5/1)
- decreasing former usual waiting time if possible (see Figure 5/2)
- preference of arranged facilities [7] (passing at locks) (see Figure 5/3).

Electronic information technology support allows continuous information flow on ships, as well. Before, shipping was conducted based on indirect central orders and today you get up-to-date direct information during shipping. It is easier to take responsible operative measures having reliable and fast resources of information.

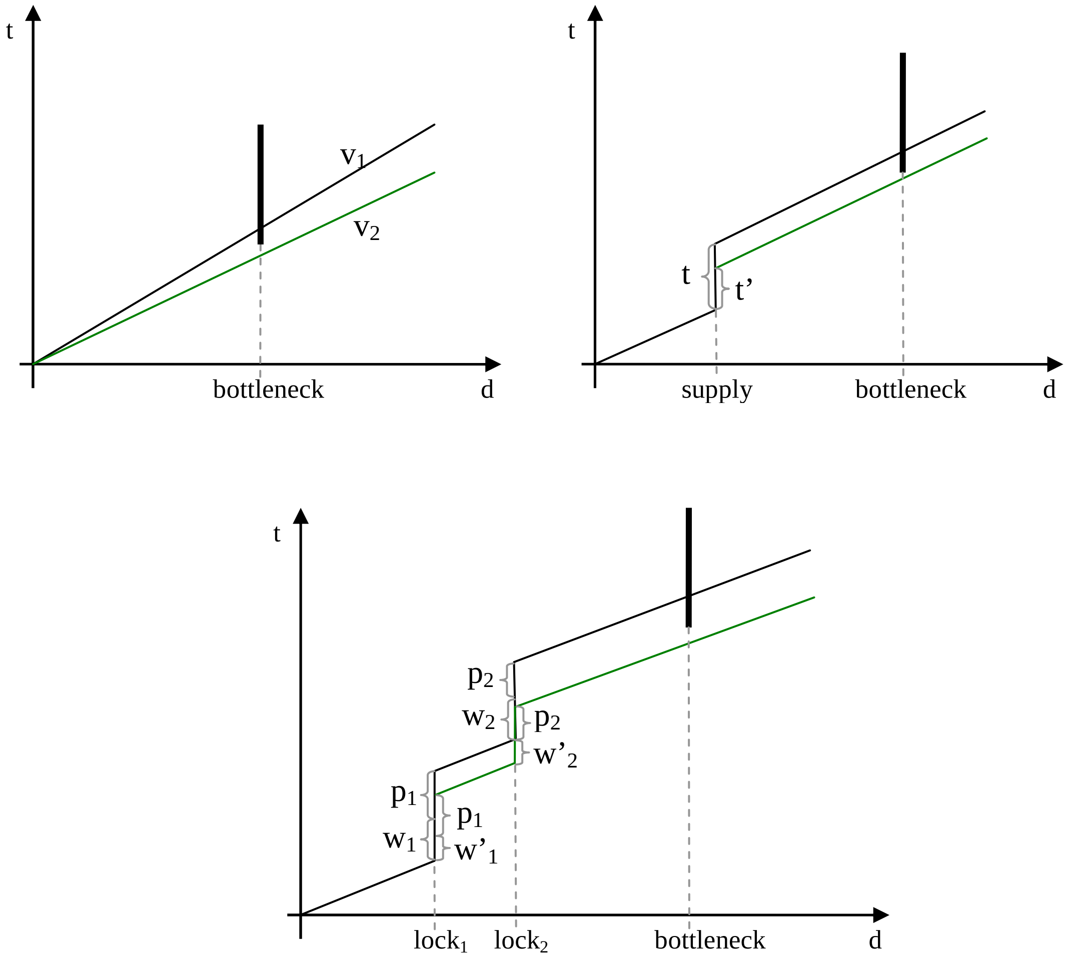

Figure 5/1-5/3: Adaptation options / timing on the way

4 RESULTS

Planning transportation tasks on river waterways traditionally is carried out by calculating parameters. Data are regarded as something static when you forecast waterway conditions based on the actual data at the time of planning.

Planning with a dynamic approach takes shipping time into account at time of the planning phase to have up-to-date data on size of inner sections. Further improvement is expected with applying potentials of 4D-shipping, which allows adjustment according to information gained during shipping.

For differences between the process and the expected results of traditional and dynamic planning see and compare Figure 6/1 and Figure 6/2.

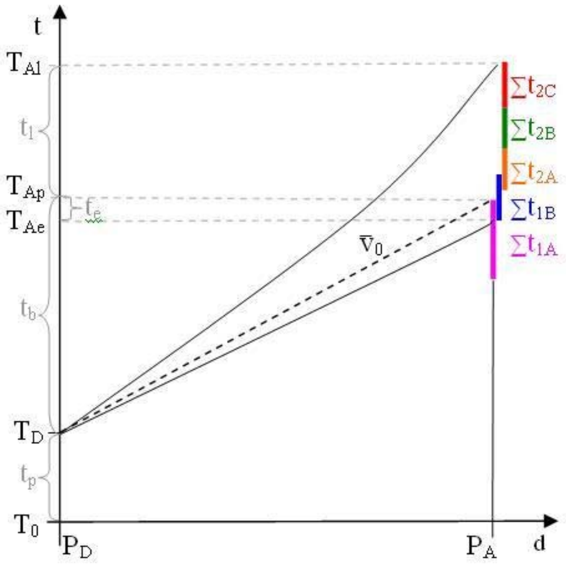

Figure 6/1: Result of static planning

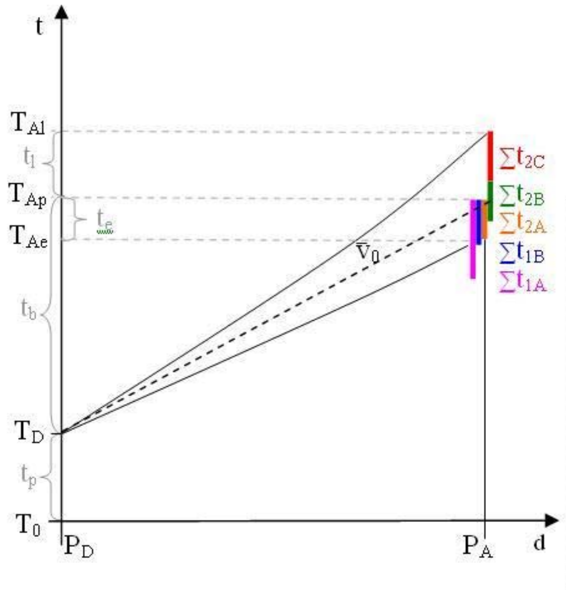

Figure 6/1: Result of dynamic planning

The types of factors affecting differences between optimum and real shipping time are as follows:

1/A: known at the planning phase
1/B: calculable at the planning phase
2/A: occurring during shipping and can be completely avoided
2/B: occurring during shipping that can be decreased and partly avoided
2/C: occurring during shipping but cannot even be resolved by using prognoses.

Classical static planning is based on types 1/A and 1/B. Without any available updated information a partial solution of problems type 2/A is only possible during transportation. 4D-shipping may be affected only by factors 2/C, by using real time data, and there is a high probability of preventing any other kind of problems. The difference between optimum and real shipping time reflects much bigger deviation with classical planning.

5 CONCLUSION

Neglect of inland waterway shipping is caused by spatial and time variability and unreliability of the waterway section. Transportation planning has great responsibility in economical supply and keeping deadlines. Considering time factor during the elaboration of the transportation task can really improve the expected result of better utilization of ships, shorter shipping time and more accurate arrival time. 4D based shipping contributes to a further increased quality. Consequently, up-to-date, modern planning methods have an improving affect on efficiency of transportation. A better utilization of ships and reliability makes shipping both for transporters and contractors a more attractive and respectful option of transportation. Hopefully, actors of the transportation field will cooperate easier and more often, and as a result, rate of river waterway transportation will increase.

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